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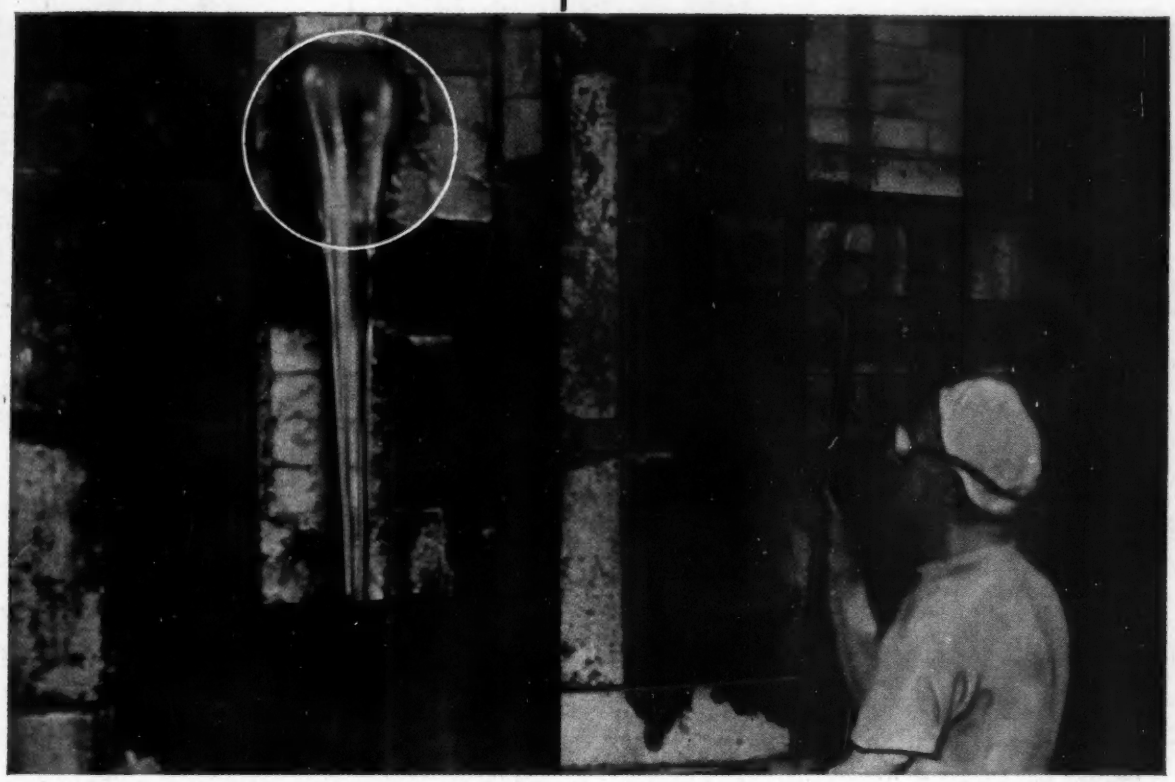

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TGA HT3

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THE ENGINEER

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CONTENTS

LEADING ARTICLES—
Significance of Calder Hall 461
Clean Air 462

ARTICLES—
Air-to-Ground Television 463
Aluminium Sheathing 487
Calder Hall Power Station. No. I. (Illus.) 464
Central Electricity Authority... 482
Coal Preparation Plant in Australia ... 486
Commercial Motor Show. No. III. (Illus.) 470
Conferences on Clean Air 463
Crankshaft Hardening Plant. (Illus.)... 485
Diesel-Electric Locomotives for Eire ... 485
Engine Research 480
Engravings of 1876... 477
Fuel Efficiency Exhibition. (Illus.) ... 483
Industry and the Technical Colleges ... 463
International Astronautical Congress ... 481
Inverted Bucket Steam Trap. (Illus.) ... 487
Medium Voltage Withdrawable Switchgear. (Illus.) 486
Metal Finishing Processes 486
North of Scotland Hydro-Electric Schemes. No. VIII (Part I). (Illus.) 468
Petroleum Equipment Manufacturers' Annual Dinner 463
Pneumatic Instrumentation 463
Regrouping Water Undertakings... ... 463
Silicon Junction Rectifiers. (Illus.) ... 484
Symposium on Calder Works 468
Symposium on the Plastic Theory of Structures 484
Track Lifting and Scarifying Equipment. (Illus.) 487
Twin Screw Tug "Takoradi." (Illus.) 484
Urban Motor Roads. No. II. (Illus.) 478
37 B.H.P. Agricultural Tractor. (Illus.) 479
100 Years Ago... 462

CONTINENTAL SECTION 489

AMERICAN SECTION 491

LETTERS AND LITERATURE 474

OBITUARY—
Sir Richard Fairey... 476

SIGNIFICANCE OF CALDER HALL

On October 17th Her Majesty the Queen will open Britain's first nuclear power station at Calder Hall in Cumberland and on another page we begin a full illustrated description of that station. Four years ago Calder Hall was merely the name of a small farmhouse close to the atomic energy factory at Windscale. To-day it is a name known in all parts of the world and one which will undoubtedly pass into history. It will not be the first nuclear reactor from which steam has been raised to generate electric power. That has already been done for short periods in the United States using, for example, the EBR1 fast reactor, and in the U.S.S.R., but Calder Hall will be the first nuclear power plant in the world —with the possible exception of the U.S.S.R.—to export electrical power for public supply as a matter of routine operation. Furthermore, and of greater significance, it is the full-scale prototype of the gas-cooled graphite-moderated, natural-uranium reactor on which this country has pinned its immediate hopes of meeting the gap in our future power needs. The reasons for the choice of this type of reactor for Britain's first nuclear power plants are now well known. Yet, though the lines of development were initially restricted by the non-availability of appreciable quantities of enriched uranium and of heavy water, it would be misleading to think that the gas-cooled reactor merely offers an immediate stop-gap which will help to meet the electrical power requirements of the country until more advanced reactors can be designed. Already it is becoming evident that, throughout the world, engineers and scientists, and even politicians, are dubious about the significance of Calder Hall and, perhaps to a greater extent, about that of the improved versions of this prototype which will be built for the Central Electricity Authority. Is it in fact, when measured by standards other than Great Britain's urgent need for power, a line of reactor development that is worth following, or ought decision to wait until many more alternative systems have been compared and assessed, as is being done at present in the United States of America ?

The arguments, of course, centre on the economics of building and operating such reactors. It is probably fortunate that we in this country have already had to take a decision. The gas-cooled thermal reactor will inevitably become our standard of comparison against which we can now measure other types of reactors that may be thought suitable for development as base-load power stations. And, because we shall be building and operating such stations the standard that is set is a real, up-to-date and practical one ; and one which from the standpoint of engineering design and technology, will be constantly improved. For example, it is obviously desirable in a nuclear power station that shut-down time be reduced to a minimum. To do this, some rapid or on-load form of charge and discharge system for the reactor fuel elements is essential. At first sight this may appear to be a complication in the reactor and one that it would be advantageous if possible to avoid. Yet there is little doubt that in a few years' time the business of charging into, and discharging from, the pressure shell of a gas-cooled reactor will be reduced by the designer to a matter of routine. A limitation on the design of Calder Hall was set by the thickness of the pressure shell. Here, again, once the problem had been properly grasped, and a pressure vessel built, the difficulties could be seen in proper perspective, and this experience indicated that first ideas had been somewhat conservative. It is not, however, only on the engineering design side that crystallisation of the objective clears the ground for real technical improvement. On the scientific side as well, the decision to build a particular type of reactor sets a framework and standard for comparison with other types. The operating costs of a reactor are appreciably influenced by the cost of chemical processing and fuel fabrication. One argument used in favour of a reactor such as the homogeneous aqueous system is that it cuts out all need for fuel element manufacture, and the chemical processing plant is a small unit integral with the reactor. Undoubtedly this is attractive, and particularly so when reactors are compared in the early scheme stages. But methods of fuel element fabrication will not stand still, nor will those of chemical processing ; so that this particular advantage of a homogeneous system may cease to look so attractive in a few years' time. From the point of view of electrical power generation through a steam cycle, the possibility of operating reactors at higher temperatures is an important development, and the gas-cooled reactor appears to be ideally suited to take advantage of probable new fuel element canning materials.

All this, of course, does not mean that we should now sit back and relax our efforts. For us, as a nation depending for our livelihood on our technical skills, the forthcoming opening of Calder Hall will be both a climax to past achievement, of which we can be proud, and a challenge to produce something better in the future. It will also be a demonstration to the world of our ability to establish a nuclear power industry here and now and not at a remote and as yet unspecified date. Apart however, from any other considerations of costs, it is essential if we are to meet our own rising demand for electrical power that we deploy our limited scientific and technical effort in such a way as to get eventually the maximum possible nuclear

power capacity for the money we are prepared to invest. Calder Hall and its immediate successors—the Stage 1 reactors for which this week the British Electricity Authority received detailed tenders—set a standard of comparison which has been achieved by the adoption of a bold and courageous policy. Not least important in this policy has been the selection of a limited objective and the refusal to allow technical and scientific effort to become bogged down in the mass of attractive reactor systems that all appear worth studying. The choice of future systems for study and development on a full-scale will not be easy; but, provided that in making such choice these systems are measured against the gas-cooled reactor, then we should be assured of a steadily developing nuclear power industry.

CLEAN AIR

The passing of the Clean Air Act into law is leading, fruitfully we hope, to the publication of much explanatory material and to the arrangement of a number of conferences. To-day, for example, Sir Hugh Beaver, whose name will remain for ever indissolubly connected with the Act, is presenting the Des Voeux Memorial Lecture before the Southport Conference of the National Smoke Abatement Society. Almost without exception the papers presented at that Conference refer to the situation created by the passing of the Act and discuss the implementation of the Act or some special aspect of air pollution in the light of the new law. As we write there lies on the table before us an illustrated supplement to the *Leeds Journal* published by the Leeds Chamber of Commerce, entitled "Clean Air" and containing a number of articles instructive to fuel users; and in this month's issue of the *Chartered Mechanical Engineer* the Institution of Mechanical Engineers announces details of a Conference on "The Mechanical Engineer's Contribution to Clean Air," to be held next February. This activity suggests that all concerned—the public as represented by the Society, industry, commerce and local authorities, as represented by the Supplement to the *Leeds Journal*, and engineers as represented by the "Mechanicals" forthcoming conference—are enthusiastically determined that the Act shall be enforced and not allowed to fall into disuse. Those who have had the chance to see how great an improvement has been wrought by vigorous action in certain American cities and those who, visiting, for example, Swiss cities, sigh for similarly clean conditions in English industrial areas' will certainly hope so. For the old North Country saying that where there is muck there is money is now out of date. The greater the publicity given to the subject of clean air by conferences and articles the more rapidly will that point be appreciated.

Under the terms of the Act, which industrialists should study in detail for themselves, the emission of dark smoke, grit and dust, will be prohibited as from a date in 1958. But there are certain "escape" clauses; and under certain circumstances exemption from the terms of the Act can be claimed up to 1963. In general the responsibility for implementing the Act is laid upon local authorities. But for certain industrial processes, more particularly those in which technical difficulty is experienced in preventing the emission of smoke, fumes, grit and dust, administration will be in the hands of the Alkali Inspectorate, which, incidentally, now appears to need a change of title to accord with its new duties. Success or failure in carrying out the will of Parliament that air pollution shall gradually cease depends, however, primarily upon the enthusiasm or the lack of it which will be shown in the coming years by local authorities and upon their success or failure in recruiting suitable staff. About half the smoke pollution over the whole country comes from domestic chimneys. But, curiously enough, considering how very many people are involved, the business of reducing this pollution appears administratively quite straightforward. The gradual expansion of "smoke control areas" and "smokeless zones," of which several already exist, including one covering the City of London, will slowly but surely reduce this source of pollution; and the rate of expansion will be controlled by the rate at which supplies of smokeless fuels and suitable burning appliances become available. The question does arise, however, as to whose responsibility it is to see that the expansion of such supplies is rigorously pressed forward. Domestically there are no such tricky questions to be solved as some industrial users of smoke-producing fuels may pose, though there will certainly be a need for local authorities to preach and explain to householders before smokeless zones are created.

But industrially, local authorities—and even more so the Alkali Inspectorate—may well find the situation more complex. For quite apart from the sheer recalcitrance that a few firms may exhibit, there are bound to be occasions when industry and authority fail to see eye to eye. For example, the Central Electricity Authority would be unlikely to take kindly to a demand that capital be expended upon an obsolete power station only kept in commission to help in meeting peak load demand and intended as soon as possible to be taken out of use. But if the date of taking the station out of commission were constantly postponed—as it might well be at a time of rapidly growing demand—the local authority might regard the plea as inadequate. A similar argument, of course, applies to other industrial plant, including steam shunting locomotives, whose replacement by diesels or by electrification cannot be expected for many years to come. There is room, too, for disagreement over the significance of the "escape" and "exemption" clauses of the Act. Too liberal an interpretation of them could make the Act a dead letter. But for a great many fuel users, the majority of engineering firms amongst them, compliance with the terms of the Act is unlikely to impose any real hardship; for the emission of smoke from a furnace, and even to some extent dust and grit, is evidence of inefficient operation and, therefore, of waste of fuel. What has stood in the way of improvement in the past, we believe, has been not recalcitrance of industrial fuel users but the lack of incentive to do better when, as in many industries, fuel costs are a small fraction of total costs and, in any case, one smokeless chimney amongst hundreds still smoking could do no good.

The Engineer

100 Years Ago

(OCTOBER 3, 1856)

"LONDON OMNIBUSES"

"Cribbed, cabined and confined—such is the character of London omnibuses, and such is the character of their builders. If you want a familiar sample of our fine old institutions, dear to routine, stolidity and stagnation, take a London omnibus, with its precipitous entrance, its straw-littered floor, its fuzzy padding, its unkind interior, destitute of hand-rails or pillars in aid of desperate passengers, its procrustean capacity, and its stifling atmosphere or killing ventilation. To begin with the capacity, impenetrable builders insist that in London streets larger omnibuses could not be tolerated, as if we, the omnibus public, did not perfectly well know that great lumbering waggons, double the capacity of an omnibus, did every day traverse our streets, not, certainly, without causing interruption, but at least compatibly enough with the other traffic. We have been at the pains to measure the interior of some of our omnibuses, and find that they measure from eight feet four inches to eight feet nine inches in length, along the seat, which allows from sixteen and a-half to seventeen and a-half inches for each passenger, six in the row. . . .

"We may now only allude to the precipitous entrance of omnibuses. The height from the pavement to the door-sill is about two feet six inches, and how many steps do you suppose there are to get up? One only. And frequently the ascent is unequally divided, so as to oblige you, gymnastically, to hoist yourself up, eighteen inches at a time. Now, what is all this for? Nothing at all, but that in many classes of private carriages there is but one intermediate step, which they copy instinctively, like Chinese, without reflecting that the circumstances are not the same. Private vehicles draw up to the kerb, and render the step easy, and at the entrances to public buildings steps are built into the edge of the footpath, for the purposes of ascent and descent; whereas omnibuses set you down in the wide streets, where you may tilt yourself or sprain an ancle in clearing the next horse's head. Remedy: make two steps. We shall watch with interest future proceedings."

A Seven Day Journal

Conferences on Clean Air

THE twenty-third annual conference of the National Smoke Abatement Society is being held at Southport this week. It began on Wednesday morning with an address by the president, Sir Ernest Smith, after which Mr. Enoch Powell, Parliamentary Secretary to the Ministry of Housing and Local Government, spoke on "The Clean Air Act." The implications of this Act are naturally the principal theme of the conference, and the Des Voeux memorial lecture, which is being delivered this morning by Sir Hugh Beaver, is entitled "Clean Air: the Next Step." An announcement has been made this week about another conference on clean air, which is to be held in London on February 19th, 20th and 21st next. It is sponsored by the Institution of Mechanical Engineers, and is known as the Conference on the Mechanical Engineer's Contribution to Clean Air. Captain William Gregson is chairman of the organising committee, and he has emphasised that the implementation of the Clean Air Act will very largely involve thought and action by mechanical engineers. The papers to be presented for discussion at this conference will deal with the smokeless combustion of coal and fuel oil in large boilers; preventing the emission of grit, dust and smoke; flue gas washing; the scope for improvement in metallurgical and ceramics works; dust control in the cement industry; air pollution prevention in the chemical industry and in coal mines; air pollution from road transport, and the elimination of smoke from locomotives. A number of bodies interested in the subject of clean air have been invited to participate in the conference. Full details may be obtained from the Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1.

Industry and the Technical Colleges

SOME of the current problems confronting industry and the technical colleges are reviewed in a booklet which has been published this week by the Federation of British Industries. The booklet has been compiled by the Joint F.B.I.-Technical Colleges Committee in the hope that it will prove useful to the discussion of some of the important issues associated with technical education. The F.B.I. urges that there should be greater co-operation, both formally and informally, between industry and the technical colleges, for "unless they are aware of each other's activities, the colleges will not be able to provide what is needed and industry will not reap the full benefit of the resources at its disposal." The booklet comments on the encouraging growth in the number of employees who are granted day release by their employers in order to attend courses at technical colleges. At the same time, it is pointed out that the success of present efforts to increase the output of the technical colleges, both quantitatively and qualitatively, will depend principally upon their ability to attract adequate numbers of suitably qualified teachers. The F.B.I. says that though there are indications that suitable applicants are being attracted in larger numbers, the position is still serious and requires close attention. It is suggested that two valuable ways in which industry can help the technical colleges in this matter are: assistance in the recruitment of part-time lecturers, and co-operation in enabling full-time teachers to be seconded to industry for periods of up to one year so that they may keep themselves professionally up-to-date. In the booklet, there are set out several recommendations to industry and to the technical colleges. Among those to industry are that directors and senior executives should be prepared to serve on governing bodies, advisory councils and regional councils, and that the results of industry-sponsored research at technical colleges should be published wherever possible. Among the recommendations to technical colleges are that colleges should be prepared to adjust courses and teaching methods to the changing needs of industry, that syllabuses of vocational courses should contain a proportion of liberal subjects, and that secondary school boys and girls should be more fully informed of facilities for further education available at technical colleges.

Regrouping Water Undertakings

THE Ministry of Housing and Local Government is pressing for a more rapid regrouping of water undertakings. The Minister, Mr. Duncan Sandys, recently sent a circular letter on this topic to the various water concerns in England and Wales, and the same aim was stressed in a speech made by the Parliamentary Secretary, Mr. Enoch Powell, when he opened the Friar's Wash pumping station, a joint venture of the Luton Water Company and the Eastern Gas Board, on September 27th. In the Minister's view, the process of regrouping which has been taking place very gradually since the passing of the Water Act, 1945, should now be tackled faster and much more radically. There are at present over 1000 statutory water undertakings in England and Wales. Mr. Enoch Powell affirmed that the small water undertaker had in the past done pioneer and excellent work. But without large financial resources, full-time qualified supervision and adequate staff, it was difficult for water undertakers to-day either to maintain the highest standards of current supply or to secure the economic and timely utilisation of the water resources of an appropriate area. That was why, he affirmed, in many parts of the country the regrouping of undertakings was an urgent economic need.

Pneumatic Instrumentation

LAST week Negretti and Zambra, Ltd., held a *Pneutechnique* Exhibition at the Criterion Restaurant. Featured was a range of detection, recording and control equipment functioning on air pressure instead of the more usual electric potential. Transducers to establish a linear relation between temperature or other physical variables and air pressure are operated on the force balance principle, moving parts being supported on diaphragms; friction and inertia are claimed to be negligible. A variety of controllers are available: the motors supplying a time base and driving the recorder charts are the only electric components. Control can be proportional, with 150 per cent proportional band or, in some cases, an infinitely wide proportional band; integral or derivative functions are also available, and either or both can be added to proportional control with no interaction. Provision is made for immediate switching from manual to automatic control when steady conditions prevail. Simple programmes can be preselected and followed automatically after manual initiation. The entire system is run from a source of clean air at up to 60 lb per square inch. Also on display were galvanometric instruments, including a pyrometer responding to the infra-red sensitivity of a transistor.

Air-to-Ground Television

ON September 20th, a Bristol "Sycamore" helicopter took off from Parker's Piece, Cambridge, carrying a Pye television camera and transmitter. Viewers on the ground saw displayed on a 21in screen oblique views of Cambridge from the air and close-ups of the aircraft instruments. The equipment demonstrated had a range of about 4 miles, but increases up to 100 miles are considered within reach. Occulting reflection from the rotor blades is one of the problems met when employing a rotary wing aircraft to carry the transmitter, but this is compensated by the ability to hover and observe a situation developing. This demonstration was attended by representatives of air and ground forces, police, and foreign powers.

Petroleum Equipment Manufacturers' Annual Dinner

ON September 27th the Council of British Manufacturers of Petroleum Equipment, which has now been in existence for thirteen years, held its second annual dinner. Mr. G. V. Sims, chairman of the Council, said that orders placed in this country by the petroleum industry were at the rate of £130 million this year, compared with £123½ million last year. Great interest was being shown in the Chemical and Petroleum Engineering Exhibition, to be held at Olympia during June, 1958, and exhibition space was fast being taken up. The principal speaker was Mr. Peter Garran, C.M.G., H.M. Minister (Commercial) in Washington. Speaking about export prospects to the U.S.A., Mr. Garran said he thought the difficulties of this market were generally overestimated. It was in fact one of our steadiest markets, and total exports in 1955 had amounted to £199 million, compared with £128 million in 1950. This year exports had been 15 per cent higher than last year. In view of the constant expansion of the U.S. economy, there were important possibilities for increasing our exports both of capital and of consumer goods, in spite of competition from other countries. Another possibility was the marketing of our techniques and processes. Two reasons why our abilities were insufficiently known were the vast size of the U.S.A. and the constant barrage of advertising from domestic firms. A long-term public relations operation on a broad front was required, visits by senior executives being especially important. The commercial services at over twenty British Consulates, working in collaboration with the Dollar Export Council, were available, through the Board of Trade or the British Embassy at Washington, to assist with local problems. In the U.S.A., and also in Canada, goods "were sold and not bought." The chief points to watch in business with America were accurate assessment of actual market requirements, firm deliveries, efficient after-sales service, and good personal contacts.

Calder Hall Power Station

No. I

Calder Hall "A" power station will be formally opened by Her Majesty the Queen on October 17th, three and a half years after the design team started work on the scheme. It is the first nuclear power station to generate electricity on an industrial scale. The main plant consists of two gas-cooled graphite-moderated natural uranium reactors, the heat from which is taken by the coolant, carbon dioxide under pressure, to heat exchangers where steam is generated for the four 23MW turbo-alternators. The reactor is designed for the production of plutonium as well as the generation of electricity. An identical station, known as Calder Hall "B," is under construction on an adjoining site and is due to be completed in 1958.

THE opening of Calder Hall power station by Her Majesty the Queen on October 17th will mark an epoch in the history of power development. For Calder Hall is the first power station in the world to generate electricity on an industrial scale from nuclear energy. Moreover, Calder Hall is the forerunner of a group of nuclear power stations which will constitute the first stage in Great Britain's ten-year programme for the construction of twelve nuclear power stations by 1965. The first group of these stations will be advanced versions of the Calder Hall design, based on the gas-cooled, graphite-moderated natural-uranium reactor. They will, however, have the benefit of current technical improvements, including up-rating of the reactors.

To view these developments in perspective we should look briefly at the origins of Calder Hall. The British organisation for atomic energy development began at the end of 1945, when, under the ægis of the Ministry of Supply, there was set up the Atomic Energy Research Establishment at Harwell, and a production division having its headquarters at Risley in Lancashire. Although the main task at Risley was the large-scale production of the fissile material, plutonium, a good deal of attention was given to the problems of power generation from reactors. Windscale, the first British plant designed to produce plutonium on an industrial scale, was a graphite-moderated, natural-uranium pile, developed from the BEPO pile at Harwell. Since the only object was the output of plutonium, the pile was air cooled and the hot air was discharged to atmosphere.

For power generation, however, thermal efficiency was important, and much of Risley's effort was devoted to investigations of heat transfer from the canned fuel to various gaseous coolants, including carbon dioxide under pressure in a steel vessel containing the reactor core.

In the meantime research work was being done at Harwell on reactors for power production and in 1951 a group was established there to prepare a design study for a reactor suitable for power generation. Natural uranium was to be used for fuel but the other main parameters, the moderator and coolant, were to be the subject of study. In the event graphite was chosen as the moderator, mainly because of the existing "know how" and because the possible alternatives, beryllium and heavy water, were not produced on a commercial scale in Great Britain. Gas cooling was preferred to liquid cooling because gases absorb far fewer neutrons. On grounds of cost and availability, carbon dioxide was chosen once it had been established that the gas would remain stable at the reactor operating temperatures and that the reactivity of carbon dioxide with the graphite moderator would not be excessive. Work was also done on the fabrication of the fuel element and on its canning.

Early in 1952 the design study for the gas-cooled graphite-moderated reactor had reached a stage when industrial participation was desirable. Engineers from the Ministry of Works, from the British Electricity Authority (now the Central Electricity Authority), and from manufacturing firms, including C. A. Parsons and Co., Ltd., Babcock and Wilcox, Ltd., and Whessoe, Ltd., were invited to co-operate.

Engineering design studies were then made for a full-scale reactor to generate well over 100MW of heat. Detailed designs emerged for the core, which was to have vertical fuel channels because of the weight to be carried in the pressure vessel, without distortion of the channels at high temperatures; similarly, designs were evolved for the pressure vessel itself; for the heat exchangers in which heat steam was to be generated at two pressures; and for the gas circulators and turbines.

Early in 1953 the Government decided to build a reactor for the dual function of producing plutonium and generating electric power. From that point the project became the responsibility of the Industrial Division at Risley. The design organisation began work in the spring of 1953; the building and civil engineering contract was placed on July 22, 1953; next week, within three and a half years of the start of the work, the power station is to be formally opened.

In Calder Hall power station there are two gas-cooled, graphite-moderated, natural uranium reactors. The usable heat from each reactor is transferred by the coolant, carbon dioxide gas operating on a pressurised closed cycle, to four heat exchangers in parallel. Steam is generated in two separate circuits in each of the heat exchangers and is supplied to four turbo-alternators in a turbine hall which is sited between the two reactor buildings, as can be seen from the accompanying illustrations. Each reactor is enclosed in a cylindrical pressure vessel with domed ends; the four heat exchangers are symmetrically disposed with respect to the reactor. Centrifugal circulators force the coolant upwards through the vertical channels in the reactor core and the hot gas is ducted from the top of the pressure vessel into the heat exchangers, the coolant circuit being as indicated in the accompanying sectional drawing.

As already indicated steam is generated at two pressures in separate circuits in the heat exchangers, and is fed separately to the high-pressure and low-pressure cylinders of the turbine. This arrangement is more efficient than a single-pressure steam cycle; it allows the cooled gas to be returned to the reactor at a lower temperature than would otherwise be possible and, therefore, a greater heat output can be obtained from the reactor with a given mass flow of coolant. To enable the reactor to be operated independently of the electrical load two separate dump condensers are installed. These dump condensers are capable of handling the full steam output of the station, by-passing the turbines. The station is served by two cooling water towers which are of conventional reinforced concrete construction, with split basins and a common pump house. The half-basin capacity is 687,500 gallons. Each tower has a capacity of 3,000,000 gallons per hour.

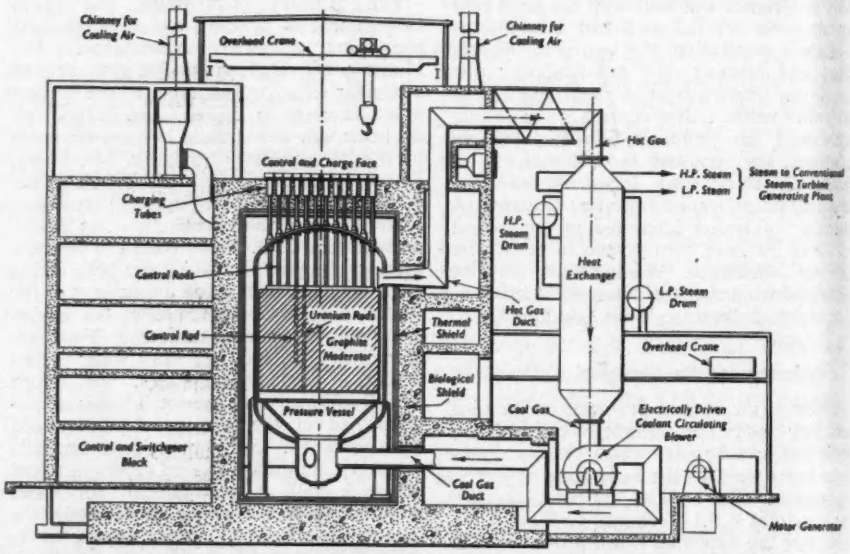


Fig. 1—Section of one of the piles at Calder Hall "A" power station, showing the reactor core, pressure vessel, thermal and biological shields and one of the four heat exchangers

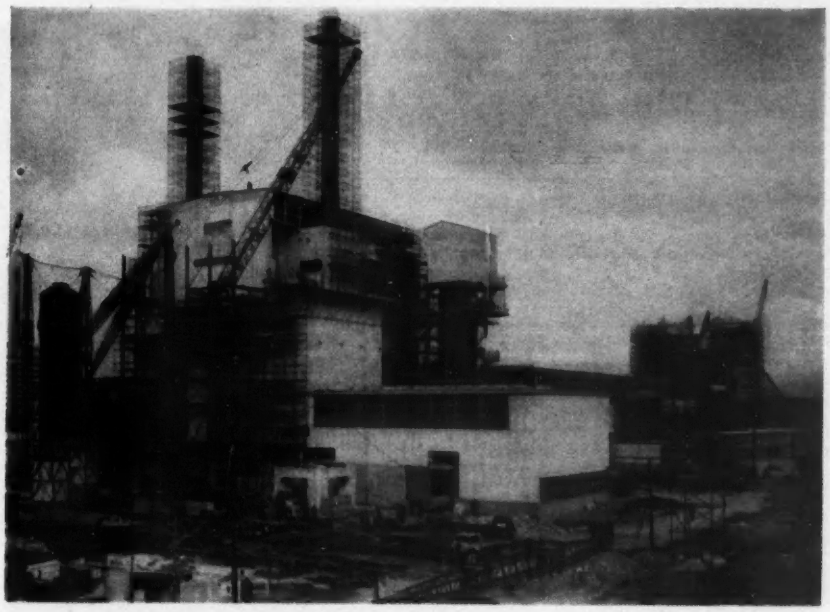
Reactor

The reactor consists of a graphite lattice structure which has a nominal core diameter of 31ft and a height of 21ft, and is contained in a cylindrical pressure vessel. To simplify the graphite structure and the design of the coolant circuit, vertical channels were adopted for the control rods and fuel elements.

The fissile material is natural uranium with a density of 18·7 grammes per cubic centimetre (or 0·676 lb per cubic inch), and the fuel elements are rods 1·15in diameter and 40in long. Each fuel element is enclosed in a magnesium alloy can with an inside diameter

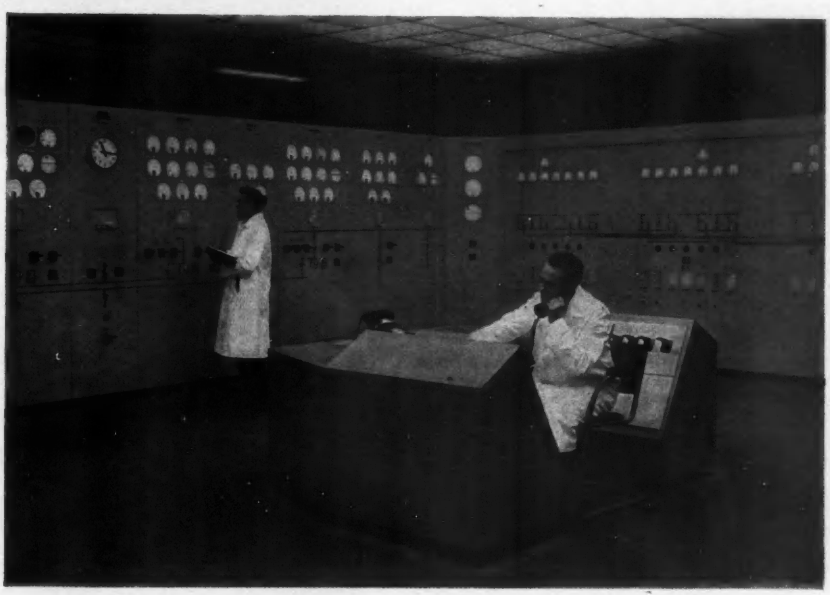
CALDER HALL POWER STATION

Calder Hall "A" power station, which is to be officially opened by Her Majesty the Queen on October 17th, is the first full-size nuclear power station in the world. Although one of its functions is the production of plutonium it is designed to make a useful contribution to the national grid, and the generating plant installed consists of four 23 MW steam turbo-alternators. The heat used for steam raising originates in two gas-cooled graphite-moderated reactors. Carbon dioxide gas at 100 lb. per square inch is the coolant. It is circulated in a closed cycle and, after abstracting heat from the reactor, it enters four heat exchangers connected in parallel and there generates steam for the turbo-alternators. Each of the two reactors is contained in a pressure vessel 60 ft. high by 40 ft. diameter, in five sections built up of 2 in. mild steel plate welded on site. The hot carbon dioxide from the reactor is discharged from the top of the pressure vessel to the four symmetrically arranged heat exchangers and then returned to the bottom of the pressure vessel casing. A 7 ft. thick concrete biological shield completely encloses the pressure vessel and, to protect the concrete shield from radiation damage there is a 6 in. thick mild steel thermal shield between the concrete and the pressure vessel.

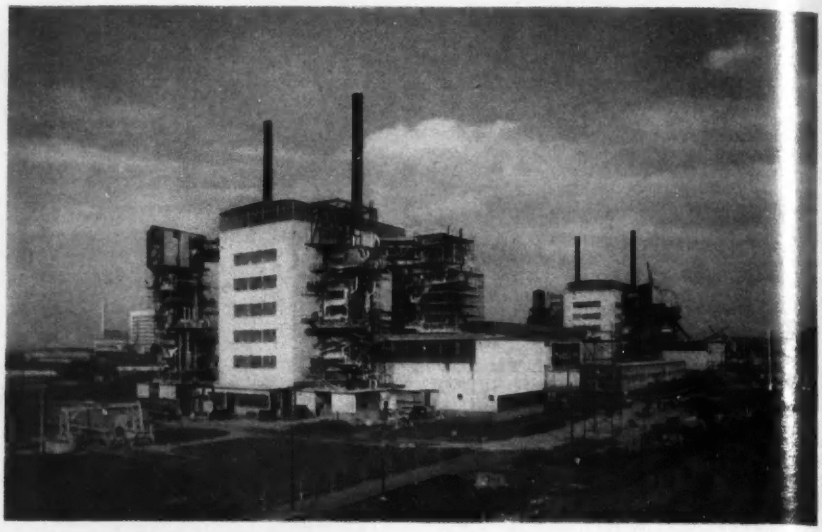


Four turbo-alternators are installed in the turbine room which is sited between the two reactors. Each set has a maximum continuous rating of 23 MW at 0.8 p.f. lagging, 3000 r.p.m. and generates at 11.5 kV. The design of the turbines is of interest because of the low steam conditions compared with those in modern solid-fuel-fired stations. Each turbine is a two-cylinder tandem machine, having a double-flow l.p. cylinder with twin exhausts to give the requisite large exhaust area combined with a relatively low blade speed. Steam from the heat exchangers is admitted at two different pressures: 198,000 lb. per hour (77 per cent of the total) is taken at stop valve conditions of 200 lb. per sq. in. abs. and 590 deg. Fah.; after the fifteenth stage a further supply of steam, 59,300 lb. per hour (23 per cent of the total) is admitted to the low-pressure cylinder at stop-valve conditions of 53 lb. per sq. in. abs. and 340 deg. Fah. The absolute pressure at the turbine exhaust flange is 1.75 in Hg and the estimated wetness of the steam entering the condenser is about 11 per cent. Regenerative feed heating is not used. Stainless iron is used for the blading throughout the turbine and the rotor blades in the last two stages of the low-pressure cylinder are fitted with erosion resisting shielding.

Most of the design of reactor control mechanisms and instrumentation had to be undertaken *ab initio*. The activity is controlled by 50 boron control rods operating in vertical channels spaced over the reactor core and parallel to the fuel channels, and the same rods are used for shut-down. An electromagnetic clutch allows each rod to be dropped for shut-down and the weight of the rod is sufficient to produce a retarded fall in the event of failure of the clutch to disengage. To avoid the use of seals on rod suspension cables or shafts the complete mechanism is enclosed within the gas coolant pressure circuit. Apparatus is installed for the detection of fission products that would enter the gas circuit in the event of a puncture in any of the fuel cans. The method of detection is based on the fact that many of the fission products have short half-lives and can be deposited on a thin wire by electrostatic precipitation and that the wire can be monitored by a counter. The orthodox side of the control of the station is represented in the accompanying view of the control room for the steam turbo-alternator plant.



The general arrangement of the power station buildings can be seen from the view of the site reproduced here. The two 120 ft. high reactor buildings of Calder Hall "A" are separated by the turbine hall and administrative block. Adjoining each reactor building is the blower house containing the CO_2 circulating plant. An identical layout is being adopted for the "duplicate" station, Calder Hall "B" which is being built with the same longitudinal axis. Work on the "A" station was started in August 1953 and will have been completed in just over three years; the "B" station was started near the end of 1955 and is due for completion in 1958. The maximum labour force engaged in construction was 1500. One of the many interesting aspects of the work was the fabrication on site and erection of the pressure vessels. All the welding was examined radiographically to Lloyd's Class 1 standards. After welding the vessels were thermally lagged and stress-relieved by applying 1.5 MW of electrical power to a heater element consisting of an internal network of tubing. Because of the protection afforded by the concrete shielding it was considered safe to use compressed air for pressure testing of the vessels.



Much of the auxiliary steam plant is fairly typical of conventional power station practice but the deviations from orthodoxy, attributable to the reactor, are of interest. A condenser is installed, as usual below each turbine but there are two separate "dump" condensers which are capable of accepting the whole steam output of the reactors, without passing through the turbines. Thus provision is made for the reactor to remain in operation whatever the electrical load. For this purpose h.p. and l.p. dump valves are installed in parallel with the corresponding governor valves and they automatically discharge surplus steam to the "dump" condenser. The "dump" condenser conserves feed water during periods of turbine outage and it can also be used when the plant is being started up or shut down, allowing heat to be absorbed while the pile reactivity is dying down. Some of the more orthodox plant can be seen in the accompanying view of the basement of the turbine hall which shows feed water de-aerators, steam receivers, a de-superheater and the feed cooler for the heat exchangers in reactor No. 1.

Replacement of the fuel elements is done from the charging deck illustrated here. This deck constitutes the roof of the concrete shield which is pierced by charging tubes giving access to the vertical fuel channels in the reactor below. Each reactor is provided with two charging machines and two discharging machines which run on a series of parallel tracks. With the help of a cross traverser any machine can be moved on to any set of tracks and can thus be made to cover any of the vertical channels. Each of the charging and discharging machines is electrically propelled and carries a winch for raising and lowering the fuel elements. A reversing motor gives controlled winch speed variations from 175 ft. per minute down to creep speeds. The hoist cradle is fitted with an electrically-operated grab and it incorporates all the electrical cores required for operation and remote indication. An indicator on the machine shows whether the grab is closed or open and whether or not it is carrying an element and gives an indication of depth of grab and amount of cable slack. The charge machine which can be seen on the left of our picture is lightly shielded compared with the discharge machine, on the right, which has to carry heavily-radioactive spent fuel cartridges. Before charging, the plant is shut down and depressurised.

of 1·165in and an outside diameter of 1·30in. To increase the heat transfer area the outside surface of the can is in the form of a single-start helical fin with an overall diameter of 2·125in. One end of the can is sealed by a plug and end cap and the other by an end cap and spacer, which locates the next can in the same channel. There are 1696 fuel element channels, 4in in diameter, in the graphite structure, and each channel can house four fuel elements. The annular channels between the graphite moderator and the fuel elements and the control rods constitute passages for the coolant flow.

The weight of the graphite structure is 1200 tons and it is supported on a structure consisting of an I-section beam in the form of a ring with intersecting I-section beams, making up a rectangular lattice or grid.

Across the members of the lattice are bolted 4in thick steel base plates which have holes in them to coincide with the channels in the graphite. These base plates support the graphite through a number of races, which allow for differential thermal expansion of the grid and graphite. The weight of graphite and grid is taken by brackets through the walls of the pressure vessel on to ten inverted A-frames (Fig. 2) which rest on the thermal shield. These A-frames are loosely bolted to the brackets on the pressure vessel and on to the thermal shield, the three contact surfaces of each A-frame being radiused. Thus allowance is made for radial thermal expansion of the pressure vessel and grid, when the A-frames roll slightly out of the vertical and the bolts ensure that the rolling surfaces do not slip.

Pressure Vessel

The design of the pressure vessel, which is 40ft in diameter and about 60ft high, posed some interesting problems. Because of the need to extract heat from the reactor at a sufficiently high temperature for steam raising it was desirable to choose the highest practicable operating pressure for the coolant. The maximum practicable wall thickness for the pressure vessel was therefore desirable. On the other hand, the pressure vessel, because of its size, had to be fabricated on site. The wall thickness was therefore limited to a value which could be satisfactorily welded. At the time the vessel was being designed it was considered that 2in was the maximum thickness of metal that could reasonably be welded on site to the required standards, subject to radiographic inspection.

Accordingly, 2in welded steel plate was used for the pressure vessel. All the fabrication was done on site, the vessel being built up in five main sections, namely, the bottom dome, the grid structure for supporting the graphite, the two parallel cylindrical sections and the top dome. When completed, each of the five sections was transported to the final erection area, where a 100-ton crane lifted them and lowered them through the roof of the reactor vault. After each section was lowered into place the final welds were done *in situ*. Each butt weld was subjected to 100 per cent radiographic inspection and all important fillet welds were examined by crack-detection methods.

Upon completion of welding the pressure vessels were thermally insulated and stress-relieved by radiant heat derived from a network of tubing which was rigged up inside the vessels and supplied with electricity, the peak loading being 1½MW. After several days the soaking temperature of 550 deg. Cent. was reached and was then maintained for eight hours before allowing the structure to cool slowly and evenly.

Testing of the vessel under air pressure instead of hydraulic pressure was deemed to be feasible because of the protection afforded by the concrete radiation shield surrounding the pressure vessel. Hydraulic testing, on the other hand, would have overloaded the supporting structure. To minimise the potential hazard of air testing, strain gauges were used during the test to indicate the general stress level and to serve as a check on those areas where locally high stresses might be expected. Brittle lacquer was used as a coarse check. About 350 gauges were used on the first test, where, after a preliminary run (from zero, to 50 lb per square inch, to zero) to check drift, pressure was applied in increments to 135 lb per square inch gauge. At each pressure stage a full set of readings was taken from the strain gauges and any which showed that stresses were significant were checked more frequently. Brittle lacquer was examined at each stage after pressure had been dropped 10 lb per square inch gauge from that at which strain gauge readings had been taken and stresses calculated; dimensional changes were recorded concurrently. The initial cold air test was followed by a vacuum test; when the vessels were loaded with graphite the cold air test was repeated to 115 lb per square inch gauge, this being followed by a hot test to the same pressure with air at a temperature of 284 deg. Fah.

The main contractor for the pressure vessels was Whessoe, Ltd., Darlington. The inspection service, some details of which are given above, was provided by Lloyd's Register of Shipping, Land Division. This service covered a survey of the pressure plant, that is, reactors, heat exchangers and gas ducting, including valves and expansion bellows, during construction, and testing in the manufacturer's workshops and on site. The material used for the manufacture of the pressure vessel was Consett "Low-Temperature Aluminium-Killed High Manganese" mild steel. It was chosen for its good impact ductility at low temperature and its consequent suitability for site welding and because its lower transition temperature is raised by irradiation.

The pressure vessel is surrounded by a concrete biological shield, the sides of which are 7ft thick, while the top is 8ft thick. This shield is octagonal in plan and the inner faces are lined with a thermal shield built up of steel plates 6in thick; similar plates form the floor and roof of the thermal shield.

Between the thermal shield and the concrete wall there is a 6in gap. To remove the heat generated in the thermal shield air is blown up this gap and is discharged from twin stacks in the roof. A view, looking down into the reactor chamber during the construction of the thermal shield, is shown in Fig. 2. Plates for the thermal shield were supplied by the English Steel Corporation, Ltd., Sheffield, and by the Steel Company of Wales, Ltd., Port Talbot.

Charge and Discharge of Fuel Elements

Charging and discharging of the fuel elements is done from the floor of the charging chamber (illustrated in Plate 2), which forms the roof of the reactor shielding. Access to the fuel channels is obtained through branches which extend upwards, from the top dome of the pressure vessel, through the roof shield, to the floor of the charging chamber. Each branch in the pressure vessel serves sixteen fuel channels. Loading and unloading is done through a charging chute which is lowered by an overhead crane into the required pressure vessel branch. The chute can be actuated to enable each fuel channel to be connected, in turn, with the floor of the charging chamber. A charging machine is then positioned over the top of the charging chute.

Each reactor is equipped with two mobile machines for charging and two machines for discharging, the two latter being provided with heavy shielding so that the "hot" fuel elements can be handled in safety. In each machine there is a detachable magazine containing enough fuel elements to fill four channels. The machines are electrically-propelled and equipped with a winch for raising and lowering the elements. A variable-speed reversing motor drives the winch at operating speeds up to 175ft per minute, with provision for creep speeds near the ends of the travel. In operation the element is held by an automatic electrically-operated grab which is fitted to the end of the hoist cable.

The hoist cable also carries the necessary wires for operation and remote indication of the state of grab, showing whether the grab is open or closed, whether it is in contact with an element and whether it is carrying an element.* On the machine there is also indication of the grab depth, the amount of slack cable and of the position of the magazine. There are interlocks to prevent maloperation and safety devices to stop the motor in the event of slack cable or over-tension. Control levers and indicators are grouped on each machine so that all motions can be controlled by an operator seated on the machine.

To give any machine access to any of the vertical channels parallel steel rails are fitted in the floor. Any machine can travel along a set of rails under its own power and can be transferred from one set of rails to another by a traverser which moves along rails at right angles to the parallel tracks.

A typical sequence of operations for discharging and charging fuel elements in a reactor is as follows. First the plant is shut down and depressurised. Then the cover plate on the required charge tube is removed and a temporary valve and gland assembly is fitted in place of the cover plate. The shield plug is withdrawn through the gland and is replaced by a guide chute, whereupon the temporary valve and gland is removed; loss of coolant is prevented by a valve on the chute. Next a purged discharge machine is aligned over the guide chute and connected to it. The chute and machine valves are then opened and the grab is lowered to seize the element and hoist it into the magazine. The magazine is then moved one pitch and the cycle is repeated until all the elements are removed from the channel. After closing the chute and machine valves the discharge machine is moved away from the chute and its place is taken by a charge machine from which fresh elements are loaded into the empty channels.

To dispose of the spent elements the discharge machine is moved by the traverser over a circular well. The shield is removed from the bottom of the discharge machine and the sliding door which normally covers the well is drawn aside. An electric hoist then lowers the magazine containing the spent elements. At the bottom of the well, near ground level, the magazine is immersed in water contained in a thick-walled cast iron tank which is wheel mounted and is electrically propelled to the storage pond.

* Paper, "Mechanical Engineering Features of the Calder Hall Nuclear Power Station," Fifth World Power Conference, Vienna, 1956.

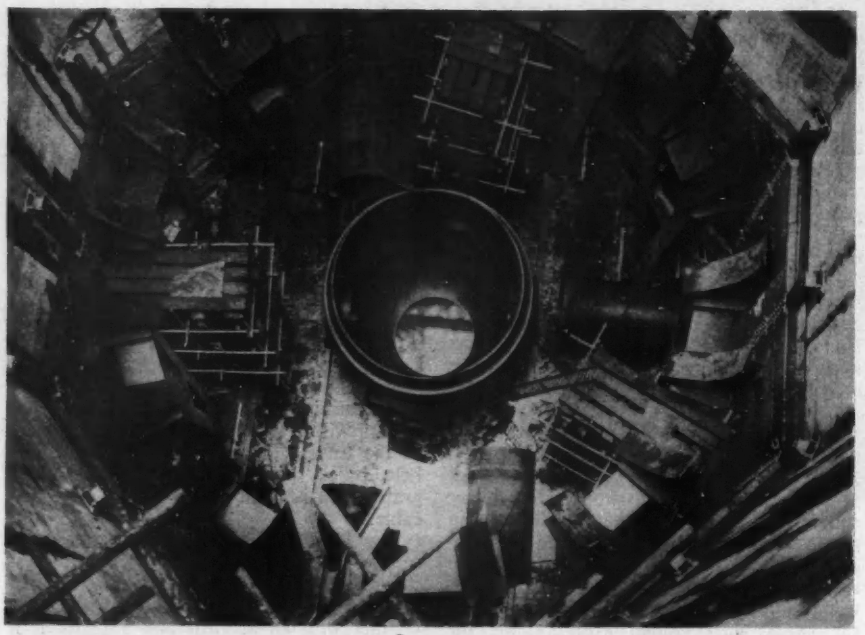


Fig. 2—Reactor chamber at Calder Hall during erection of thermal shield plates. On the floor of the chamber is the inlet manifold, whereby coolant from the four heat exchangers is admitted to the bottom of the pressure vessel. The octagonal chamber is 45ft across and 80ft high

Control Rod System

Four main considerations, some of them mutually conflicting, affected the design of the control rod mechanism, operating in vertical channels in the reactor core : reliability of operation ; failure to safety under all conditions ; limitation of space, and the fact that the mechanism would operate at a high temperature in a CO_2 atmosphere free of oxygen and water vapour and liable to neutron bombardment. The fourth requirement gave rise to serious lubrication problems.

To meet these requirements a control rod system for Calder Hall power station was developed by Metropolitan-Vickers Electrical Company, Ltd., for the U.K. Atomic Energy Authority. The design evolved combines the functions of control and shut-off and sixty such actuating mechanisms have been supplied for each of the two piles.

The boron control rod assembly weighs 130 lb, has a working travel of 21ft, and is suspended from the control mechanism by a special low-cobalt flexible stainless steel cable, edge wound between the side cheeks of a drum. This drum is operated through spur and bevel gear trains by a synchronous motor. Because the control rods operate in vertical channels gravity fall can be used when the rods are required for shut off and an electromagnetic clutch is, therefore, incorporated in the mechanism to allow free fall of the rods. An eddy-current brake is also included in the system so that a high launching speed can be achieved, with slow touch down. Indication of the rod position is given remotely by a magslip position indicator.

Since the whole mechanism (including motor, clutch, brake, winch and gearbox and position indicator) is enclosed in the CO_2 coolant circuit no pressure seals are required on rotating shafts or suspension cables ; glass-to-metal seals were used to take the only other external connections, the electric cables, through the pressure casing.

In the absence of oxygen normal lubricating oils are unsuitable and in the absence of water vapour graphite lubrication is equally unsatisfactory. After considerable research the problem was solved by the use of a dry lubricant in the form of a molybdenum disulphide (MoS_2) treatment.

Control Rod System Performance.—The system provides for the operation of the control rod actuating mechanisms in two groups :

(1) "Coarse" operates up to sixty actuating mechanisms.

(2) "Fine" operates up to four actuating mechanisms.

For "coarse" operation three control rod speeds are available :

(*a*) In (fast) 50in per minute maximum (2·1cm per second).

(*b*) In (normal) 5in per minute maximum (0·21cm per second).

(*c*) Out (normal) 0·5in per minute maximum (0·021cm per second).

With all the rods moving together the "out" speed limits the maximum rate of release of reactivity to 2×10^{-6} per second.†

For "fine" manual control an approximate maximum "in" and "out" rod speed of 50in per minute is possible. During the period of commissioning only, fast speeds "in" and "out" are made available by the incorporation of special test equipment.

The shut-off performance of each rod is :

(1) Initial acceleration not less than 2ft per square second.

(2) Maximum speed 4ft per second.

(3) A travel of 18ft 6in in a time not greater than five seconds.

(4) Touchdown speed not greater than 6in per second.

Design of Actuating Mechanism.—The actuating mechanism is shown in Fig. 3.

A synchronous driving motor of the variable reluctance design is used ; it has a three-phase wound stator, class "H" insulated, and an unwound rotor, and it was chosen to meet the following requirements :

(1) Synchronous operation.

(2) Positive holding torque at standstill.

(3) No brushgear, to give greater reliability.

(4) High torque-to-volume ratio.

(5) Capable of working in an ambient temperature up to 100 deg. Cent.

(6) Capable of running at low speed so that a small gear ratio could be employed to permit back driving by the rod during shut-off.

A solenoid clutch is fitted between the motor shaft and the remainder of the mechanism, to disengage the rotor of the motor from the system, thereby reducing the inertia to be accelerated during shut-off. The clutch is operated by six solenoids energised from the same supply as the motor. If the rotor of the motor should fail to be disengaged when the supply is opened, then shut-off action will still result because the de-energised motor is back-driven. If there is loss of drive, an emergency winding handle can be attached which mechanically engages the clutch.

The eddy-current brake, which provides controlled fall of the rod, consists of two sets of permanent magnets with alternately opposed north and south poles. An eddy-current copper-clad steel disc rotates in the air gap between the magnets. The braking torque on the disc is controlled by varying the air gap magnetic flux with a magnetic shunt mechanically operated from a cam. The correct rate of fall under shut-off conditions is programmed by the profile of the cam. From the motor the drive is via single-stage spur gearing and right-angled bevel gears, giving a total reduction of 20 : 1.

Linear measurement of the rod position is provided by a transmitter magslip driven by a gear train from a cable-driven measuring wheel. A lever-operated switch with a "follower" wheel on the winding cable detects "no-tension." This switch is used in conjunction with a second switch operated by the magnet shunt control cam to detect "over-run or lost rod." The second switch is also used to check that the cam is correctly set.

After tests had been completed on individual components extensive life tests were carried out on two actuating mechanisms which were run in an atmosphere of pure dry CO_2 with not more than 0·01 per cent by volume O_2 impurity at a pressure of 100 lb per square inch. In Fig. 4 we show the actuating mechanisms seated on the test pressure vessels, lagged to simulate the thermal effects of the biological shield ; heating was incorporated equivalent to the heat flow up a charge tube. The actuating mechanisms were run for successive tests at the highest rod speed of 50in per minute and reversed automatically at the top and bottom of the rod travel. During the tests the following main points were studied : wearing properties of gears and bearings treated with MoS_2, temperature rises, effects of thermal cycling and the functional operation of components. Special measuring techniques were developed to obtain this information without opening up the actuating mechanism.

Design of the Control System.—The control system provides for the raising and lowering of the control rods by the variation in frequency and phase-sequence of the three-phase a.c. supplies to the driving motors of the actuating mechanisms. A range of frequencies 0 c/s to 1·3 c/s, with a constant voltage of 40V r.m.s., is employed ; the zero-frequency condition is used for "holding" the rods.

"Coarse" and "fine" control supplies to any of the actuating mechanisms are selected by means of changeover switches mounted in distribution cubicles. These switches are connected to the main and auxiliary busbars to which are fed "coarse" and "fine" supplies, respectively.

† Paper No. 15, "Equipment for Control of the Reactor," Symposium on Calder Works Nuclear Power Plant, British Nuclear Energy Conference, 1956, Bowen and Ghalib.

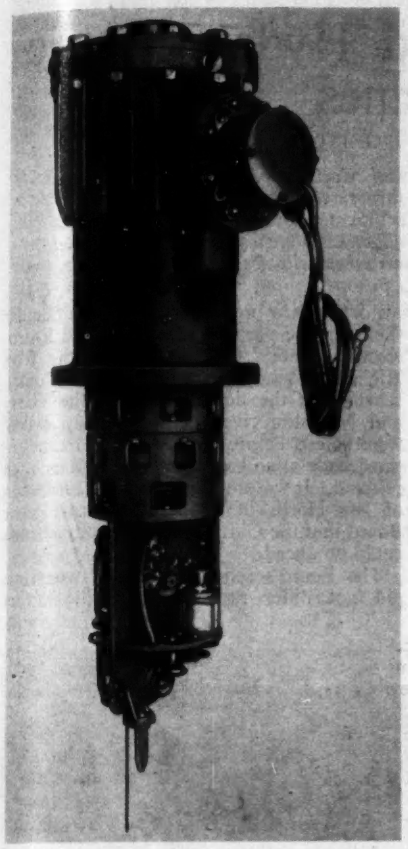


Fig. 3—Control rod actuating mechanism. The cable carrying the control rod is driven through spur and bevel gears by a synchronous motor. An eddy current brake provides controlled fall

The coarse supply is generated by one of two identical frequency converter sets—the other frequency converter set being purely on stand-by duty. Operation of the frequency converter sets is carried out from a machine operator's control desk. Position control of the "coarse" rods *en bloc* is provided by means of a control switch and a magslip indicator, giving rod travel which is transmitted from the frequency-converter set.

"Fine" control supplies are provided by two sine-potentiometers mounted in the cubicles shown in Fig. 5. Each sine-potentiometer is basically a resistor chain fed by d.c. and tapped to give a sinusoidal distribution of potential. The tapping points are taken out to studs on a face plate from which three sets of brushes pick off an output three-phase supply at a frequency equal to the rate of rotation of the brushes. Position control of the "fine" rods is carried out at the reactor control desk by means of manual drives to the sine-potentiometers. Rod travel is given by "M" type indicators operating from the outputs of the sine-potentiometers.

A three-phase voltmeter was developed to give a direct reading of the equivalent r.m.s. voltage down to zero frequency; it is the larger of the two instruments which can be seen in Fig. 5. The voltmeter uses a three-to-two-phase transformation, thereby requiring only two moving-iron elements on the same shaft.

Each frequency converter set consists of a 37·5 h.p. induction driving motor, a 22kVA salient pole a.c. generator; a differential gearbox and a 19·4kVA frequency converter mounted in line on a common bedplate. The motor is started direct-on-line by closing the 415V circuit breaker; it is designed to deliver full load torque even if the terminal voltage falls to 50 per cent of its normal value. Furthermore, the a.c. generator is excited from the 50V station battery which enables the stored energy of the frequency converter set to maintain continuity of the output supply for the maximum time when running down in the event of fault conditions on the 415V a.c. supply.

The frequency converter has no stator winding, is rotor fed and gives a three-phase output of 40V r.m.s. with frequencies 0 c/s to 1·3 c/s. Its input supply from the a.c. generator is taken to the rotor through six sliprings. A three-phase output is taken from brush arms arranged around the commutators. The power required to drive it (equal only to its friction and windage losses) is supplied by the induction motor through the differential gearbox. If the input and output shafts of the gearbox are rotating at the same speed, the frequency converter is running in synchronism with the a.c. generator and the output derived from its commutator is of zero frequency. The values of current drawn from the three output brushes will depend on the positional relationship between the rotors of the two machines. If a decrement of speed is fed into the differential gearbox through its pilot motor section (described later) the frequency converter runs sub-synchronously with respect to the a.c. generator and a three-phase supply can be drawn from its commutator, the frequency corresponding to the difference in rotational speeds of the two machines. If an increment of speed is fed into the gearbox the frequency converter will run super-synchronously with respect to the a.c. generator and, again, a three-phase supply will be available at its commutator with a frequency corresponding to the difference in rotational speeds of the machines, but having a phase sequence which is the reverse of that obtained with sub-synchronous running. The voltage of the output is independent of the frequency converter speed and is determined purely by the a.c. generator excitation.

Fig. 4—Two control rod actuating mechanisms are shown here seated on test pressure vessels

Fig. 5—Main sine-potentiometer cubicle containing two sine-potentiometers for providing "fine" control supplies to the control rod actuating mechanisms

The system is designed to move the rods "in" when the frequency converter is running sub-synchronously so that in the event of a failure of drive to the frequency converter the system will fail to safety by moving the rods "in."

Any normal three-phase relationship between the zero frequency voltages at the frequency converter output terminals can be achieved when the machine is running synchronously by operating the differential gearbox to bring the rotors of the a.c. generator and frequency converter into the correct relative position; this relationship is partly dependent on the load.

The differential section of the gearbox is of the sun and planet epicyclic type. Drive to the third member of the differential is through an irreversible worm from a small pilot motor via one of three permanently meshed gear ratios selected by individual electromagnetic disc clutches having stationary windings. An electromagnetic brake is applied to the third member shaft when no drive is selected by the coarse control switch on the reactor control desk. An indicating dial attached to the main gearbox housing indicates the position of the differential cage which can be manually moved over a restricted angle to facilitate paralleling of the two frequency converter sets during change-over. Indication of the coarse rod travel is also transmitted from the differential gearbox to the reactor control desk.

To ensure continuity of the coarse control supply at the main busbars during change-over of the frequency converter sets it is necessary to parallel the incoming frequency converter set before transferring the load. The line contactors are interlocked to ensure correct paralleling of the incoming set and the control selector switch is automatically interlocked so that the incoming set must be carrying the load before the outgoing set is tripped off the main busbars.

A magslip indicator associated with each actuating mechanism shows the position of each rod. The indicator also carries two lamps which indicate "no-tension" and "lost or overrun rod," which are operated

from the switches in the actuating mechanisms via fault-finding relay circuits.

Two safety circuits detect the following :—

(1) Faults which necessitate de-energising the actuating mechanisms and dropping the rods, so initiating a shut-down of the reactor. (2) Faults which prevent further movement of the rods.

An emergency shut-down of the reactor is initiated from the emergency push button on the reactor control desk or from one of the shut-down circuits. All the line contactors and 415V circuit breakers are opened, thus removing the control supply from the main busbars and thereby de-energising the actuating mechanisms so that the rods give shut-off action. At the same time, the sine-potentiometer supply is tripped so that the fine rods also give a shut-off action.

The main turbines and a.c. generators are tripped from relays operating on under-voltage at the main busbars, so preventing the turbines being motored.

(*To be continued*)

Symposium on Calder Works

A SYMPOSIUM of nineteen papers on the Calder Hall plant will be held by the British Nuclear Energy Conference, on November 22 and 23, 1956, at the Central Hall, Westminster. Particulars are obtainable from The Secretary, British Nuclear Energy Conference, 1–7, Great George Street, Westminster, London, S.W.1.

Session 1 : Introduction and General Design (November 22nd, 10 a.m.–12.30 p.m.)—Chairman, Sir John Cockcroft. (1) "The Place of the Calder Hall Type of Reactor in Nuclear Power Generation," by Sir Christopher Hinton. (2) "The 1951–53 Harwell Design Study," by R. V. Moore and B. L. Goodlet. (3) "The Design and Construction of the Plant," by R. V. Moore.

Session 2 : Technical Research Problems (November 22nd, 2 p.m.–5 p.m.).—Chairman, Sir John Cockcroft. (4) "Heat-Transfer Experiments on the Fuel Elements," by P. Fortescue and W. B. Hall. (5) "Experimental Physics," by P. W. Mummery. (6) "Shield Design," by C. C. Horton and W. Bonsall. (7) "Basic Design of Reactor," by G. Packman and B. Cutts. (8) "Early Metallurgical Problems," by R. A. U. Huddle and L. M. Wyatt. (9) "Metallurgical Developments," by L. Grainger and A. B. McIntosh.

Session 3 : Engineering Design (November 23rd, 10 a.m.–12.30 p.m.).—Chairman, Mr. W. L. Owen. (10) "Design and Construction of Reactor Vessel," by G. Brown, M. J. Noone and R. F. Bishop. (11) "Uranium Fuel Handling," by K. H. Dent and G. W. Grossmith. (12) "Design of Important Plant Items," by A. T. Bowden and G. H. Martin. (13) "Steam-Cycle Analysis," by W. R. Wootton. (14) "Design and Construction of Heat Exchangers," by H. Morris and W. R. Wootton.

Session 4 : Light Engineering and Electrical (November 23rd, 2 p.m.–4.30 p.m.).—Chairman, Mr. J. Eccles. (15) "Equipment for Control of the Reactor," by S. A. Ghalib and J. H. Bowen. (16) "Detection of Faulty Fuel Elements," by E. Long, J. M. Laithwaite and K. W. Cunningham. (17) "Reactor Control and Instrumentation," by R. J. Cox and K. R. Sandiford. (18) "System Control and Protection," by E. Anderson and J. H. Bowen.

Session 5 : Future Developments and Summary (November 23rd, 5.30 p.m.–7.15 p.m.).—Chairman, Sir John Cockcroft. (19) "Future Developments of Gas-Cooled Reactors," by R. V. Moore.

North of Scotland Hydro-Electric Schemes

No. VIII : THE GARRY AND MORISTON SCHEMES—PART I*

The adjoining catchments of the Garry and Moriston rivers in Inverness-shire have for many years been recognised as favourable sources for the development of hydro-electric power. The North of Scotland Hydro-Electric Board's developments here will yield about 383 million kWh annually, from an installed capacity of 106MW. The design of the two schemes is described in this article.

THE hydro-electric works in Glen Garry and Glen Moriston give us a noteworthy addition to this series of articles on Scottish water power. The two schemes, taken together, are large by comparison with others in Scotland, and they include various technical innovations. The Garry scheme is the more advanced of the two, and is now substantially completed and is due to be inaugurated to-day, October 5th. The upper section of the Moriston Scheme is almost as advanced (power is expected from it soon), but the lower section will not be producing power until next year. The Garry scheme includes, amongst its more interesting technical features, a rockfill dam at Quoich (shown in Fig. 1), and a horizontal turbo-alternator set—largely an experimental arrangement—in its upper power station. In the Moriston scheme, the Trief process, using blast-furnace slag, has been used for the mass concrete of the two dams of the upper section and some other works. And the two power stations of the scheme are being built underground, with similar hydraulic characteristics so that three identical 16MW turbo-alternator sets can be installed as the principal generating plant of the scheme.

Although the two schemes are nominally distinct, it is convenient to consider them together here, particularly on account of the history of their promotion, in which a familiar theme in the promotion of Highland hydro-electric schemes recurs. Bills for the West Highland scheme, and the Caledonian scheme, as the development of the Garry and Moriston rivers was variously called, were placed before Parliament four times in the decade or so before the war, and as often rejected. It was not until after the formation of the North of Scotland Hydro-Electric Board that the Garry and Moriston schemes could go ahead.

The Board's schemes for the two rivers did not differ radically from the earlier rejected schemes, but paid much more attention to "amenity" and to the needs of agriculture and salmon. These matters do not go to the heart of the pre-war opposition, however, and it may be of interest to recall here some facts from THE ENGINEER of March 27, 1936, at the time when the first attempt at promoting the Caledonian scheme had just been rejected. The Bill had been promoted by the British Oxygen Company with the object of utilising a source of cheap power for the manufacture of calcium carbide. Manufacture of carbide in Britain was considered a national asset by the Bill's supporters ; but its opponents considered that a factory should, instead, be erected in South Wales, which was then a distressed area. We described the proposals in some detail, showing the various works on a map, and pointing out that the scheme would be capable of generating about 50,000 h.p. continuously, i.e. about 327×10^6kWh

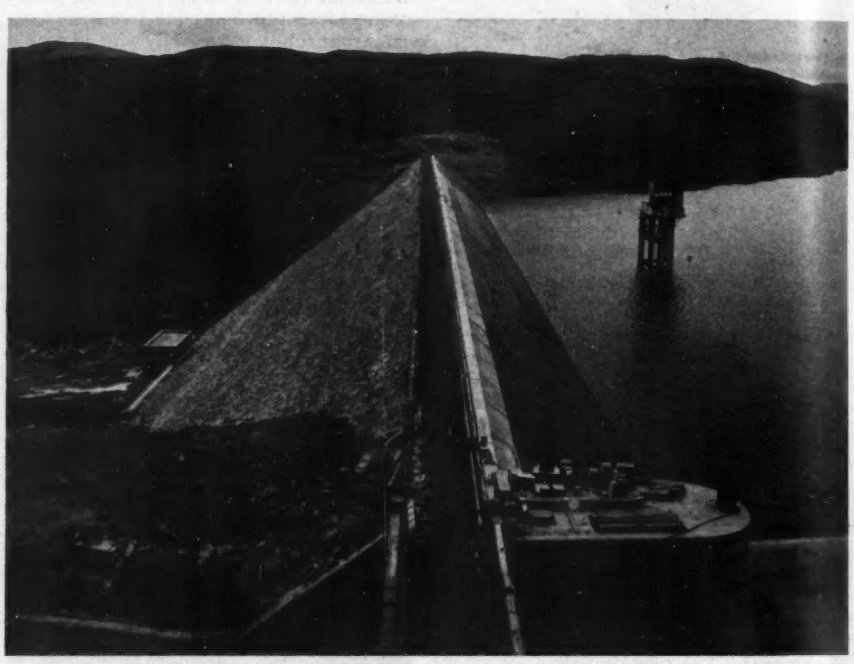


Fig. 1—Quoich rockfill dam. The reinforced concrete slabs on the upstream face comprise the sealing membrane. The downstream face is of hand-packed stone ; the bridge in the foreground spans the spillway channel

* No. I : "An Introductory Survey," appeared July 14, 1950 ; No. II : "The Loch Sloy Project," July 21-August 4, 1950 ; No. III : "The Fannich Project," June 8-15, 1951 ; No. IV : "The Mullardoch-Fasnakyle-Affric Project," April 11-25, 1952 ; No. V : "Some Schemes for Local Supply," October 16-23, 1953 ; No. VI : "The Tummel Garry Scheme," September 2-23, 1955 ; No. VII : "The Shira Scheme," April 20-27, 1956.

annually, a figure not very different from that of the Board's present scheme. The Bill had been rejected on the motion for second reading—that is to say, without detailed discussion. In a leading article commenting on the situation, we affirmed that "There is in the Bill not a single clause which could not have been dealt with adequately in Committee," and we also remarked that "Had it been a National Bill, had the Government itself decided to carry out the proposed works, there is little reason to doubt that the Socialists would have found in its clauses as many reasons for supporting it as they found on Wednesday, March 18th, for opposing it."† All this contention is now, happily, past history, and new schemes are, in these days, able to be judged solely on their own merits.

The Hydro-Electric Board's Schemes

The Board's own proposals have been modified somewhat since the constructional schemes (Numbers 23 and 24) were published in 1948, largely owing to the adoption of underground power stations on the Moriston scheme. The two schemes as actually constructed, are shown in Fig. 2, and the principal data relating to them are listed in Tables I and II.

The Garry scheme consists of a large reservoir at Loch Quoich, at the head of the system, with diversion works leading to the upper power station about 3 miles further down the Garry.‡ The reservoir of the lower works is several miles further down the river, and leads to somewhat similar diversion works culminating in a power station which discharges into the Garry just above its junction with Loch Oich, in the Great Glen. The catchment area draining into the main reservoir is about one-third of the total for the scheme, but because the rainfall is more intense on the higher ground, about a half of the flow available in the lower works comes from the upper reservoir.

The scheme originally envisaged a subsidiary power station, centred on Loch Lundie, and discharging into the tunnel of the lower stage works, but this proposal has not yet been investigated in detail. A further potential source of power, also not yet investigated in detail, might be the utilisation of the head of 50ft between the two stages of the scheme, by a low head development at Loch Poulary.

The Moriston scheme is similar in its general layout. The upper stage, however, has two reservoirs, Loyne and Cluanie, connected by a tunnel. The diversion works lead from the Cluanie reservoir and pick up the waters from two left bank tributaries, the Peathrain and the Doe, the second of which may be the site of a subsidiary power station at a later stage of the work. Ceannacroc power station is built underground, near the foot of the pressure shaft. Its short tail-race tunnel discharges back into the river, and there is a gap of some miles, as in the Garry scheme, before the headpond of the second stage is reached. The lower works will consist of a dam, forming a headpond on the Moriston, with an intake leading into a vertical shaft, communicating with the turbines in the underground power station immediately below the dam. A long unlined tail-race tunnel will lead from the power station to the Moriston River close to the point where it flows into Loch Ness. A second catchment on the left bank—the Livishie—offers resources for a subsidiary scheme discharging its water into the Glen Moriston reservoir.

The two subsidiary schemes, on the Doe and the Livishie are still at an early stage of investigation, and so we cannot yet give any further details about them, save to mention that both of them would consist of extensive aqueducts, collecting the flow from a series of streams, and feeding a power station which, in its turn, would discharge into the main section of the scheme, just above the corresponding main power station.

Moriston is the first scheme in Scotland where underground power stations have been used, except for one or two minor applications (namely a subsidiary station of the Affric scheme, and the Morar power station), and excepting also the Clachan station of the Shira scheme which we recently described. The principal advantage in this case is in the lower section of the scheme, where it has been possible to site the power station immediately below the dam. The long tail-race tunnel will be unlined, except in any places where bad rock is met, and the principal saving of the scheme lies here, for the estimated cost of lining the tunnel with concrete and steel pipes, which would have been necessary had the power station been above ground (its length is 22,000ft and its equivalent diameter 20ft 9in) is about £800,000. There are however, other economies in the arrangement which have proved particularly suitable for the lower Moriston works. The rock at the

Table II—*Reservoirs and Hydrology of the Garry and Moriston Schemes*

	Garry scheme		Moriston scheme		
	Quoich	Invergarry	Loyne	Cluanie	Glen Moriston
Useful storage capacity :					
Cubic feet × 10^6	12,500	825	1,600	6,090	Negligible
In million kWh through associated stations	111·5	4·3	18·3	67·8	Negligible
Area of gathering ground, square miles	52·2	147	26·5	91 1	155
Average annual rainfall, inches	125	101	90·2	95·5	81·1
Average run-off, inches	117	91	78·2	82·5	68·1
Average flow available for power cusecs	399	806	128	464	642
Spillage and compensation losses, cusecs	51	189	8	93	140
Top water level, feet, A.O.D. (spillweir crest)	660	280	745	702	361
Maximum draw down, feet	85	12	39	67	4
Impounding dam, type	Rockfill*	Concrete, gravity/ buttress	Concrete gravity	Concrete gravity	Concrete gravity
Maximum height, feet (foundation to roadway)	122	50	58	112	47
Length, feet	1,060	150	1,745	2,165	400
Volume, cubic yards	388,000 (rockfill)	8,560 (concrete)	66,000 (concrete)	232,000 (concrete)	35,000 (concrete)
Quantity of excavation, cubic yards	62,000	11,000	56,000	90,000	30,000
Length of spillweir, feet	305	174	225	450	77
Design floods :					
Normal maximum, cusecs	6,000	13,000	2,400	4,200	15,000
Corresponding rise in reservoir level, feet	3	4·7	2·3	2·2	Nil
Catastrophic cusecs	10,000	21,000	5,100	8,500	30,000
Corresponding rise in reservoir level	4·1	10	3·9	3·4	2·0

* There are also two concrete gravity dams at the upper end of Quoich reservoir.
Note.—The gathering grounds of the Doe and Livishie schemes are 18·5 and 15·2 square miles in extent, respectively, and the rainfalls 95·5in and 58·85in. The Livishie scheme thus has a run-off equivalent to 45·5in, giving 46 cusecs available for power generation.

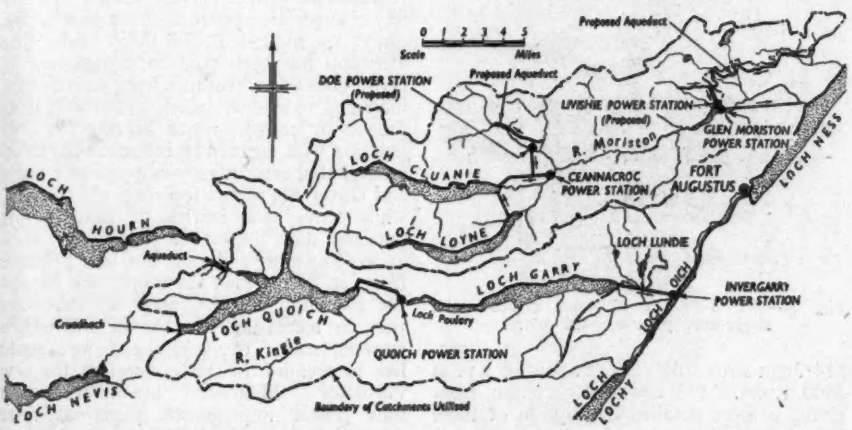


Fig. 2—Principal works for the hydro-electric exploitation of the Garry and Moriston Rivers

† Ninety-five Conservative votes were recorded against the Bill, as well as the block of 102 negative Socialist votes.

‡ In the pre-war scheme it was first proposed that the Quoich reservoir should be diverted to flow westwards to Loch Hourn, but this idea was changed following criticism that such a diversion would affect the régime of the River Ness unfavourably.

Table I—*Power Stations of the Garry and Moriston Schemes*

	Installed capacity, MW		Mean annual output, kWh × 10^6	Annual load factor, per cent	Average gross head, feet	Flow at rated capacity and mean head (cusecs)
	Sets	Total				
Garry :						
Quoich	1×22	22	77	40	312	1034
Invergarry	1×20	20	82	47	169	1737
Compensation water stations :						
Quoich dam	1×0·350	0·350	2·6	85	113·8	45
Invergarry dam	1×0·285	0·315	1·4	43	27	162
	1×0·030					
Totals for Garry scheme	—	42·665	163	—	—	—
Moriston :						
Ceannacroc	1×16	20	76·2	40	276	1070
	1×4					
Glen Moriston	2×16	32	120·2	41	310·5	1720
Loyne	1×0·55	0·55	1·2	25	17·5	514
Compensation water stations :						
Cluanie dam	1×0·30	0·30	2·1	80	89	48
Dundreggan dam	1×0·165	0·165	0·6	46	43·5	51
Left bank extensions :						
Doe	Under consideration		20	—	—	—
Livishie						
Totals for Moriston scheme	—	64·015	220·3	—	—	—

power station site is not ideal—it is a psammitic schist—but this fact was heavily outweighed by the other advantages. The construction of about 4 miles of transmission line was also saved by siting the power station in its present position.

At the Ceannacroc power station, the rock is excellent for an underground design. But the advantage of the underground over the surface arrangement was reduced because it is a tail development ; a long head tunnel lined with concrete was needed to pick up the side-streams. The two stations, Ceannacroc and Glen Moriston, were also arranged to have almost identical hydraulic conditions. It was then possible to order three identical 16MW sets for the two stations (one for Ceannacroc and two for Glen Moriston) with consequent economy and improvement of the delivery dates.

Amenity and Salmon

Before passing to a detailed description of the two schemes, some points in common between them in the treatment of the problems of amenity and salmon spawning may be briefly noted. In both schemes the upper reservoirs are large, and the lower ones relatively restricted, so that the effects of "draw-down," which may leave unsightly reservoir banks, are confined to the more remote localities. There is another reason, however, for this concentration of storage at the head of the scheme, apart from the hydro-electric considerations. The lower parts of the valleys are used as winter grazing for sheep and cattle ; during the summer the higher grounds and hillsides are used. Flooding of the lower valley land would upset the cycle, by taking away the winter grazing. Thus, the area taken by the lower reservoirs is small.

Fish passes have been provided at both of the lower dams. Near the outlets of both upper stations, however, there are fish hecks and traps. Ascending salmon which do not spawn in the shallows above the first dam of either river, but try to go even higher, are trapped at the heck and, if necessary, kept in pens until their spawn can be taken. The spawn is then taken to a fish hatchery which the Board operates at Invergarry.

The consulting engineers responsible to the North of Scotland Hydro-Electric Board for the Garry and Moriston schemes are Sir William Halcrow and Partners for the civil engineering, and Messrs. Kennedy and Donkin for the mechanical and electrical engineering. The architects for the Garry scheme are Messrs. Gratton and McLean, and for Moriston, Mr. Robert Hurd.

The various contractors who have carried out the works at Garry and Moriston will be mentioned at the end of the relevant sections throughout the course of this article.

One source of possible confusion should, perhaps, be mentioned. There is a second River Garry in Scotland, in Perthshire. In the sixth article in this series on the Tummel-Garry scheme, we described the hydro-electric works on that river. The Tummel-Garry scheme includes the Clunie dam and power station. These works are all separate and distinct from the Garry scheme in Inverness-shire, which we are now describing, and from the Cluanie dam of the Moriston scheme.

(To be continued)

Styrene Monomer Plant.—We are informed by the Shell Chemical Company, Ltd., that a new plant is to be built by Petrochemicals, Ltd., at Partington on the Manchester Ship Canal. The new plant is expected to be in production by 1958 and to reduce considerably the imports of monomeric styrene.

Commercial Motor Show

No. III—(*Concluded from page 433, September 28th*)

THE Commercial Motor Show at Earls Court, London, closed last Saturday, September 29th. In concluding our report on chassis and complete vehicles we now give a brief survey of the trends relating to major vehicle components and some of the more interesting proprietary units, such as engines, transmission and suspensions.

Engines

Apart from the engines already mentioned in Nos. I and II of our report, there were a few new designs, among them a horizontal version of the 200 h.p. Rolls-Royce diesel engine, a three-cylinder version of the Turner two-stroke engine and a six-cylinder 5·56-litre Perkins engine of 101·6mm bore and 114·3mm stroke, developing about 95 h.p. at 2500 r.p.m. We can easily refrain from giving a more detailed description of these power units as none of them shows any marked breakaway from orthodox design practice nor any notably new technical features. There were, however, the usual detail modifications based on road experience and alterations resulting from the adoption of advanced and more economical production methods. Such design modifications, self-evident as they are, generally pass quite unnoticed by the public, but they are just as essential to the quality of the final product as technical innovations.

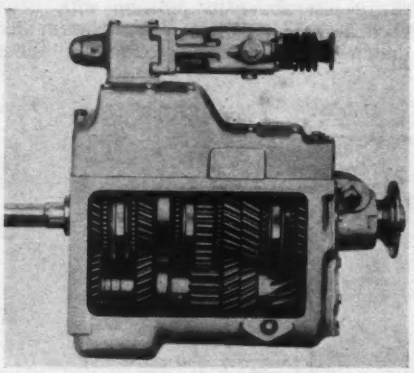


Fig. 12—Z-F 8-speed synchromesh gearbox with single lever power-assisted control

In accordance with Continental practice, engine speed has gone up, in some new designs by about 10 per cent compared to the 1954 models, and piston speeds of more than 2000ft per minute are by no means unusual. Engines with a capacity of less than 1 litre per cylinder unit are generally equipped with some form of pre-combustion chamber, while the direct injection system which gives the highest thermal efficiency and the best cold starting predominates in all bigger engines. Most direct injection engines have the combustion chamber formed in the piston crown and depend, for satisfactory distribution and combustion of the injected fuel, on an organised, essentially rotary air swirl. Progress has been made with regard to the generation of this swirl and, in several cases, suitably shaped intake ports have replaced the former masked valves. Hardly any changes are apparent in the general lay-out of the modern British diesel engine, but attention has been paid to maintaining its favourable wear resistance irrespective of the increased rotational speed. Thin wall lead-bronze or copper-bronze bearings in conjunction with nitrided or induction-hardened crankshafts, centrifugally-cast cylinder liners and chromium plated top rings are the rule, while valve seat inserts of heat-resisting material and Stellite-faced exhaust valves are coming more and more into use. Effective filtration of the fuel, the lubricating oil and the induction air also plays an important part in increasing the life of the engine between major overhauls, and we should like to mention in this connection the new Purolator "Micronic" air filter, which uses plastic impregnated paper as filter element.

So far there is not yet a definite indication that engine manufacturers are prepared to achieve a higher specific engine output by other means than raising the engine speed. Rolls-Royce diesel engines are available with mechanically driven Roots type blowers, but turbo-charging at the show was confined to two British and one Swedish engines. Both

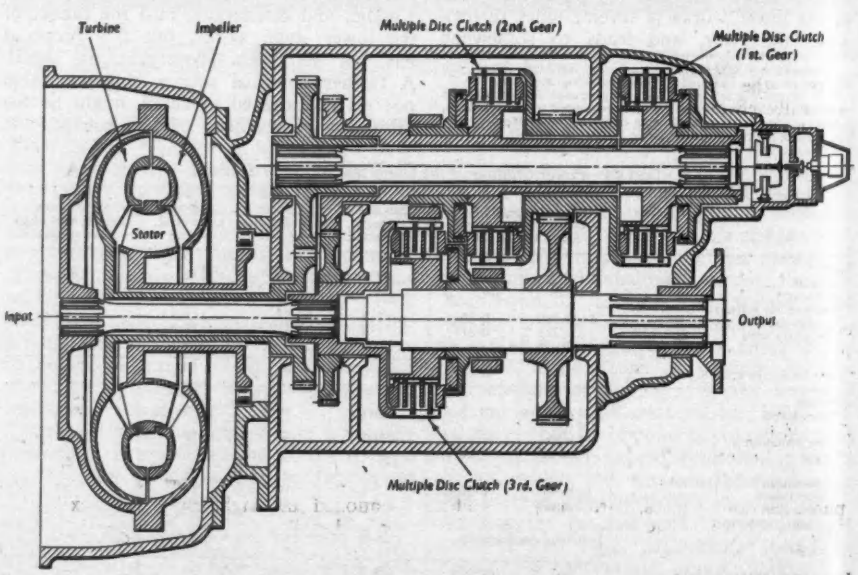


Fig. 13—Z-F torque converter and 3-speed transmission

the 10·15-litre Meadows and the 11·3-litre Thornycroft engines were fitted with Eberspacher exhaust-driven turbo-chargers, resulting in either case in a power increase of about 40 per cent compared to the normally aspirated engines. In spite of these impressive results manufacturers and users seem to be sceptical and maintain that the useful life of this turbo-charger—about 30,000 miles between major overhauls—is too short in comparison with that of the engine, and that a replacement scheme could only be carried out by a comprehensive service organisation. Considering, however, that similar objections were made years ago to the "complex" injection equipment of automotive diesel engines, it can be expected that real or assumed difficulties still associated with turbo-chargers will eventually be overcome.

While mentioning the subject of fuel injection pumps reference should be made to the C.V.A. "DPA" distributor type pump, which, fitted to a 2·26-litre engine, attracted much attention at the stands of Commer and Karrier. Itwould be wrong to conclude, from the fact that the pump was not given any particular prominence at the stand of C.A.V. and that little information was issued by the makers, that its introduction was premature. On the contrary, distributor pumps of this and similar systems have been known for some time, and have been running with great success in U.S.A. on a variety of engines ; their more general adoption in this country as well as on the Continent is only a question of time or—more probably—of expediency. The distributor pump, which was fully described in THE ENGINEER of September 14th, is considerably smaller and simpler than the orthodox multi-cylinder fuel injection pump and can be produced at lower cost, a factor particularly important in the field of small engines where the injection equipment represents a comparatively high percentage of the total cost.

TRANSMISSIONS

The design of the transmission and, particularly, of the gearbox of commercial vehicles varies considerably with their weight and with the operating conditions. The service requirements of city buses, coaches, delivery vans and heavy goods vehicles differ so greatly from one application to another that a common design to satisfy these conditions is unlikely to be developed.

It is obvious that light vehicles as delivery vans and pick-ups, which in most cases are built by motor car manufacturers and employ the same or suitably modified components taken from the car production, are fitted with synchronised four-speed gearboxes, the required transmission ratio generally effected in the final drive casing. Synchronised gearboxes are occasionally used in the 1·5–2-ton class, but as a rule the majority of medium-weight vehicles are equipped with constant-mesh boxes, a construction which seems to replace the formerly almost universal "crash" gearbox in all but the heaviest types of goods vehicles. Most, but by no means all, synchromesh gearboxes have helical spur gears, the engagement being effected in all cases by dog clutches. The constant-mesh gearbox is short and stiff and, with helical gears, moderately silent ; the gear change requires no physical effort even if the gearbox is located at some distance from the driver's seat. For this reason the constant-mesh four or five-speed gearbox is also quite popular for the lighter type of public service vehicles, particularly those for inter-urban traffic, as there seems to be no urgent need to relieve a skilled driver from the relatively simple task of gear changing.

The employment of auxiliary gearboxes, which in the past has been mainly confined to heavy load carriers and cross-country vehicles, has nowadays become more popular for medium-sized vehicles and is frequently used as an alternative to the two-speed axle to take the maximum advantage from the characteristics of the diesel engine. The auxiliary gearbox sometimes employs an epicyclic gear and is generally located in a separate housing at the output end of the main box. In cases of vehicles fitted with all-wheel drive the auxiliary box is mostly incorporated in the transfer box, which transmits the torque to the propeller shafts and contains a device for disengaging the front drive.

New auxiliary gearboxes at the show were exhibited by Moss Gear Company, by the

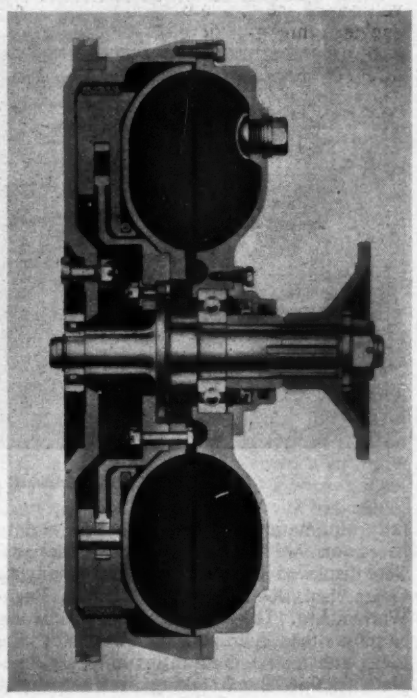


Fig. 14—Fluid coupling with direct-drive centrifugal clutch

David Brown Corporation and by Rolls-Royce, Ltd. The Rolls-Royce box has been designed to provide an increased torque spread for vehicle transmission when used behind the heavy-duty automatic gearbox of the same firm, and has additional power take-off drives to ancillary units.

An interesting example of an eight-speed synchronised gearbox designed for a maximum intake torque of 380 lb-ft was shown by Zahnradfabrik Friedrichshafen A.G. It contains in one common housing a synchronised auxiliary ratio at the intake side of a normal synchronised four-speed gear, thus giving eight forward and two reverse ratios. Thanks to the use of short positive-lock synchronisers, previously described in THE ENGINEER of April 17, 1953, the gearbox, which has a centre bearing for the better support of the shafts, is stiff and compact. All gears are selected by one gear lever, and a pneumatic power-assisted device facilitates the gear shift, particularly of the lower ratios. This box is shown in Fig. 12.

In No. I of our report we have already mentioned the eight-speed gearbox of the Leyland "Buffalo," which contains in a common housing a four-speed gear, in this case of the epicyclic type, in combination with an epicyclic auxiliary ratio on the output side. Apart from this example of a heavy goods vehicle, the use of the semi-automatic gearbox was confined at the show to heavy passenger vehicles, especially to city buses operating in heavy traffic.

All modern epicyclic gearboxes now operate the band brakes of the gear ratios by individual air or oil-actuated cylinders, and most of the development work in the last few years has been devoted to improving the remote control mechanism. The logical choice for such a system is obviously electric control, as cables are very much easier to install than hydraulic or pneumatic pipelines.

The electrical gear change control of C.A.V., Ltd., which was fitted to the A.E.C. pneumatic "Monocontrol Transmission," consists basically of a solenoid-operated valve box, located as near to the gearbox as the installation allows, and a selector switch operated by a small gear change lever conveniently placed beneath the driver's hand. The valve box incorporates a bank of five double valves, each pair of which, when actuated by the plunger of a solenoid, diverts compressed air to the corresponding gear brake cylinder ; release of the solenoid plunger permits the valve to return to its rest position, thereby sealing off the air inlet and exhausting the compressed air from the last used gear. The gear selector consists of a set of five pairs of electrical contacts, which are opened or closed as required by a cam mounted on the gear lever. A safety device prevents movement of the lever from the top gear to the bottom gear, without using the intermediate gears, and also prevents the simultaneous engagement of two gears in the event of an electric fault.

Electric control also gives the opportunity of effecting a fully automatic control for all power-operated epicyclic gearboxes. Self-Changing Gears, Ltd., the manufacturers of the "Wilson" gearbox, demonstrated such a system which relieves the driver of all gear changing and ensures that the vehicle is driven in the gear most suited to the road conditions while still allowing the driver to over-ride the automatic control and easily obtaining the gear of his choice. The system employs a small d.c. generator as the speed-sensing element and a series of voltage-sensitive relays which operate in succession to change the gear ratio by means of solenoid-operated valves as the speed of the vehicle rises. The speed at which gear changes occur are suitably modified in response to the engine torque, i.e. by the position of the accelerator pedal.

The generator is driven from the gearbox output shaft and its field winding is supplied independently by current from the vehicle's battery. The generator produces a voltage proportional to the speed of the vehicle and excites the volt-sensitive relays successively as higher voltages are generated. These relays are connected to suitably selected points of potential on a bridge potentiometer, the current in the relay circuits being made unidirectional by the use of small rectifiers. Whenever the generator voltage exceeds by a small margin the potential of any of the selected tappings on the potentiometer, the relay in that circuit closes and switches current from one solenoid-operated valve to the next, thereby engaging a higher gear. On a suitable reduction of vehicle speed and of generated voltage, the relay opens again and switches the current back to the other solenoid, thereby changing down to a lower speed ratio. A rheostat connected with the accelerator linkage reduces the current through the potentiometer in accordance

with the instantaneous engine torque ; this has the effect of reducing the potentials at the potentiometer tappings so that gear changes take place at a lower engine speed. Since the potentiometer and the generator windings are both supplied from the same source of current, any reasonable variation in supply voltage is compensated and does not affect the speeds at which gear changes are made.

A further improvement relating to transmissions, also developed by Self-Changing Gears, Ltd., is a fluid coupling, seen in Fig. 14, which combines the advantages of the latter with the positive lock afforded by the centrifugal clutch. A disc attached to the output shaft of a normal vane-type fluid coupling between the runner and the inner face of the flywheel proper, carries four brake shoes with friction material facings. They are pivoted to the disc at one end and are held in their retracted position by a garter spring when the output shaft is at rest. In action, acceleration of the engine produces torque through the fluid coupling ; as the output shaft speed rises the friction clutch shoes are thrown outward by centrifugal action so that contact with the flywheel drum is established. From this point the transmission efficiency of the fluid coupling becomes immaterial because the rising speed of the runner shaft results in the drive being taken over fully by the centrifugal clutch. It is claimed that the elimination of slip in the coupling improves the fuel consumption of a vehicle by about 3 per cent.

A gearbox which also dispenses with the main friction clutch and gives either " finger-tip " or fully automatic control, is the "Hydromedia" transmission of Zahnradfabrik Friedrichshafen, seen in Fig. 13. Designed mainly for use in city buses, it consists of a single-stage hydrodynamic torque converter coupled with a three-speed gearbox of the layshaft type, the individual gear ratios of which are engaged by hydraulically actuated multi-disc clutches. The converter has a maximum conversion ratio of 2·5 : 1 and consists of an impeller, a turbine and a reaction member which, during the conversion period, is held stationary by a free-wheel device. Two gear trains to the layshaft are provided at the intake side of the gearbox, one coupled directly with the impeller and, therefore, with the crankshaft of the engine, and the other one through a hollow shaft with the turbine runner. The helical constant-mesh gear wheels are engaged by multi-plate steel-disc clutches, one on the main shaft and two on the layshaft, with the exception of the reverse gear, which is engaged by a dog clutch. They are actuated by pressure plates, rotating in unison with the clutch housing, and receive oil under pressure through bores in the main and layshaft. Two gear pumps circulate oil through the converter and supply the oil pressure to the individual clutches via a distributor valve which can be equipped with electromagnetic or mechanical control. In the former case an additional mechanism giving fully automatic control can be supplied.

Other examples of torque converters and fully automatic epicyclic gearboxes, mainly based on well-known American designs, were displayed at the stands of Self-Changing Gears, Ltd., Rolls-Royce, Ltd., and Borg-Warner, Ltd. The Borg-Warner transmission employs the hydraulic converter for the lower and intermediate ratios only, a single-plate friction clutch taking over the direct drive.

Also belonging to the category of automatic transmissions is the Hobbs gear, employing epicyclic gear trains in conjunction with oil-operated friction clutches and gear brakes.

Another approach to ease of control is represented by the " Newtondrive," shown by Newton and Bennett, Ltd., Valetta Road, Acton, W.3, and optional on the small Standard vehicles.

This drive employs a newly developed clutch which is illustrated in section in Fig. 15. It can be seen that when the flywheel is accelerated and the bob weights move outward, the springs must be compressed even before the pressure plate closes on the driven plate. Thus these springs serve the function of positively opening the clutch, as well as determining the load on the friction faces once the bob weights reach the limit of their travel. The " Newtondrive " clutch has been demonstrated to us in passenger cars, and we found that the quality of its performance matched the ingenuity of the design. The vehicle could be held on a gradient or inched forward in traffic at moderate revolutions per minute—the clutch commences to engage at about 800 r.p.m.—or the throttle could be swept wide open, when the engine speed would be allowed to rise and the car accelerated fiercely.

" Newtondrive," however, also exploits the ability of the synchromesh gearbox to accept unsynchronised selections. In addition to the automatic disengagement of the clutch at low revolutions per minute, a toggle mechanism of conventional pattern is provided, but actuated by a vacuum servo motor instead of a hydraulic slave cylinder. The clutch is disengaged by a vacuum reservoir, evacuated by the induction manifold depression, under the control of a solenoid valve. The solenoid circuit is energised directly by the dynamo, so that it cannot be brought into action when the engine is idling. A second valve by-passing the solenoid valve is opened when the choke is in use, so that the faster tick-over does not result in the car creeping when in gear. When the clutch is required to engage, the vacuum connection is closed, and air enters the servo cylinder through an orifice that controls the rate of engagement. When the throttle is open, an extra air bleed is opened to give faster clutch closing ; this air bleed also allows the car to be driven with the choke in action if the driver wishes.

Since the engine does the work of opening the clutch, the conventional pedal can be replaced by an electric switch, conveniently situated on the gear lever ; this may take the form of a button, or can be arranged to respond to any force on the lever. It is intended that the switch should remain closed and the clutch withdrawn throughout a gear change.

The " Newtondrive " cars which we handled were Standard vehicles with the normal clutch pedal removed. Thus it was necessary to provide for downward changes to be completed without use of the accelerator pedal during braking ; this was done by connecting the servo motor output mechanism to the throttle, so that when the clutch is withdrawn the throttle is opened to allow an engine speed of, perhaps, 1800 r.p.m. This provision affects the driving technique—when the car is brought momentarily to rest, the gear lever cannot be touched until the charging circuit cut-out has opened, or the engine will continue to run fast as first gear is selected and it engages noisily. The amount of throttle applied by this link-up is not, of course, sufficient to open the air bleed that allows the clutch to re-engage. In practice, the lack of any synchronisation renders the manual effort of gear selection remarkably high, while it would seem that, at least unless the driver acquires the trick of energising the clutch twice during, or only for the final stage of, an upward change, the gear changes will be a severe test of the durability of the centrifugal clutch.

The development of such transmission

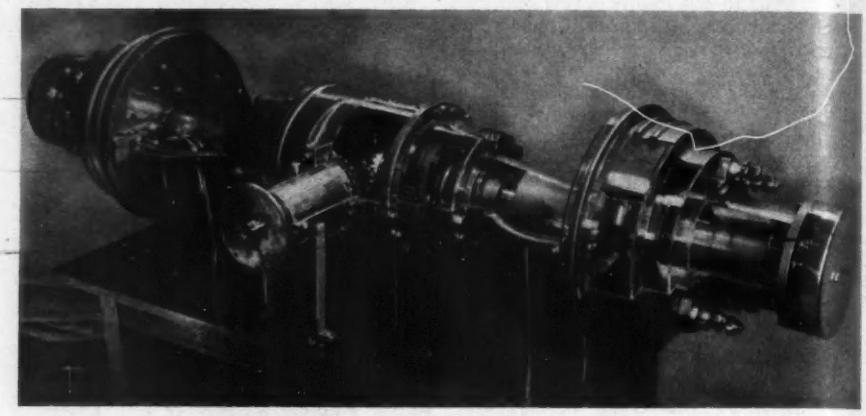


Fig. 16—Scammell double-reduction rear axle

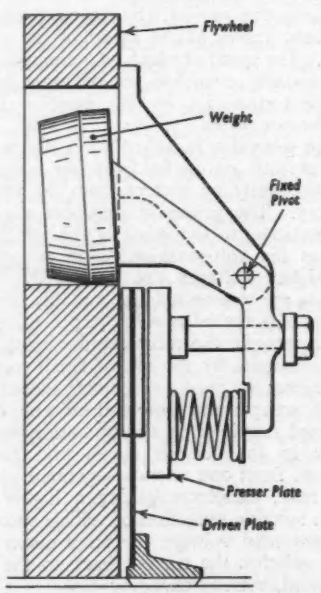


Fig. 15—"Newtondrive" centrifugal clutch

units as friction clutches, universal joints and propeller shafts has remained more or less static. These components are almost entirely proprietary products, developed to such a degree that modifications are confined to minor details only. In this connection we should like to mention that some manufacturers of heavy passenger vehicles have found it advisable to fit torsional vibration dampers to long propeller shafts, as a rule near the gearbox coupling flange to damp the resonant torsional vibrations which occur at low speeds in top gear and frequently give rise to excessive gear noise.

No innovations are to be reported as far as rear axles are concerned. The worm drive, unsurpassed for its capacity of withstanding heavy transmission and shock loads without sustaining fractures, has proved its value for many years. Owing to its inherent silence at ratios up to 10 to 1, it is the ideal drive for passenger vehicles and for heavy goods vehicles with two driven axles. The hypoid gear is coming more and more into use, especially for high reduction ratios, where the greater strength of the drive pinion gives it a definite advantage over the spiral bevel gear.

For ratios beyond the range of either worm or hypoid gear, the double reduction rear axle is the only solution. For axles of this type there seems to be a tendency to replace the formerly usual spur wheel reduction by epicyclic gears, located either in the wheel hubs (Kirkstall Forge Engineering, Ltd.), or between the differential and the half shafts (Scammell—Fig. 16).

Brakes and Steering

No particularly new trends are apparent in the design of brakes ; hydraulic brakes predominate in all but the heaviest types of vehicles, and servo assistance has become almost universal. In vehicles fitted with petrol engines the vacuum system is, of course, the most economical form of servo assistance, but it is losing ground in diesel-engined vehicles, especially in those built for export markets, in favour of the air-pressure-assisted hydraulic brake. Full air-pressure systems are confined to heavy goods and passenger vehicles, where in the former generally used plunger-operated brake cylinders are gradually being replaced by the cheaper and perfectly reliable diaphragm-operated cylinders.

In some Continental countries it is a legal requirement, where full air pressure brakes are installed, that the brakes of one set of wheels must remain in operation if an air leakage results in the loss of braking on the others. For this reason British manufacturers of such equipment, have now developed safety systems with dual control valves which deliver air from two reservoirs independently to front and rear brakes in the event of pipe failure or any other accident: an example is the Clayton Dewandre valve described on May 11th last, page 497.

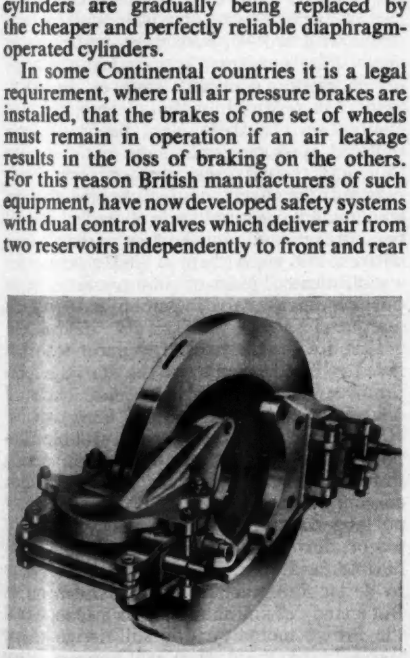


Fig. 17—A ventilated disc is used on the Lockheed transmission brake

So far the disc brake shows no sign of replacing the conventional drum brake, and the only application of this type shown at the exhibition was that of a transmission brake in the Scammell " Constructor." It is likely that the disc brake, because of its superior heat-radiating capacity, might indeed find a wider application as transmission brake than as a wheel brake, the more so as the regulations, modified in April, 1955, now permit the use of transmission hand brakes even on passenger vehicles.

The Lockheed transmission hand brake (Fig. 17) exhibited at the stand of Automotive Products Company, Ltd., is similar to the well-known service disc brake except the friction pads are not applied by hydraulic pressure cylinders, but by a cable-operated link mechanism. The cast brake disc is provided with slots between the two contact faces, which allow air to be circulated by centrifugal force, thus increasing the heat dissipation. As the transmission brake rotates at the fairly high speed of the gearbox output shaft, these slots are quite effective.

Suspensions

It would be futile to discuss whether or not the appearance on this year's show of the A.E.C. " Bridgemaster " and the Leyland " Atlantean," both buses fitted with independent front suspension, already constitutes a clearly defined trend in bus construction or merely an indication in which direction future design of public service passenger vehicles is likely to progress. Both A.E.C. and Leyland have shown that the design of an independent front suspension for a heavy vehicle can be achieved with basically the same constructional means as for a motor car, i.e. by some wishbone linkage in conjunction with either coil springs or torsion bars and direct-acting dampers. It must be admitted that design of an independent rear suspension is more complicated because the drive has to be transmitted to the rear wheels, but here again the construction of the " Bridgemaster " shows that a comparatively simple coil spring arrangement, whilst not offering independent suspension, enables the load to be carried at the extreme sides of the vehicle, thus imposing the least wracking stresses upon the body shell. By substituting springs without any noticeable internal friction in conjunction with robust dampers for leaf springs, it becomes possible to design accurately for the desired riding characteristics which, with little maintenance, can be relied upon to remain constant.

The case for the independent front wheel suspension in passenger transport vehicles is so strong that its more general introduction cannot be delayed very much longer. We are inclined to think that, after the two largest makers of heavy passenger vehicles have broken away from the classic conception of the leaf spring, other manufacturers will soon follow. The need for independent rear suspension might not yet be sufficiently urgent ; on the other hand, should public demand for such vehicles arise, for instance for luxury coaches giving a maximum of riding comfort, we are certain that such requirements can be satisfied. The recent exhibition and demonstration of military vehicles at Chertsey, arranged by the Ministry of Supply in collaboration with the S.M.M.T., showed a considerable number of scout cars, armed carriers, fire crash tenders, and other cross-country vehicles, all fitted with independent coil spring or torsion bar suspensions. There is no doubt that most of these suspension units, probably with some minor detail modifications, could be usefully adapted for civilian applications.

We should like to conclude our report with a short description of a variable spring rate rubber suspension system displayed at the stand of Metalastik, Ltd., which is being used in the service buses and long-distance coaches of the Birmingham and Midland Motor Omnibus Company. The front suspension is basically a double wishbone system with trailing arms, but the conventional coil spring has been replaced by a flexible cylindrical block consisting of alternate layers of thick rubber and thin metal plates. This block is connected directly between the inner face of the kingpin and an angular bracket

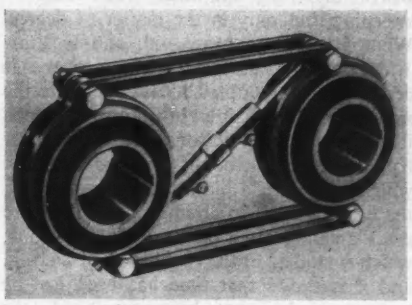


Fig. 18—Rear suspension unit of Birmingham and Midland Motor Omnibus single-decker

on the outer face of a chassis cross member. When the wheel is deflected upwards relative to the chassis both the compression and the shear of the rubber are increased, but by reason of the arcuate movement of the outer ends of the transverse links the rate of change of compression increases as the load increases ; hence the non-linear stiffness characteristic.

In the case of the rear suspension, four toggle links locate the live rear axle longitudinally, transversely and against the torque reactions : one is seen in Fig. 18. In the tare load position the links are all horizontal, and the weight is then resisted by torsion of the rubber bushes, of which the inner sleeves are keyed to the anchor brackets of the rear axle and to the attachment points of the vehicle body. Deflection in either direction from this position involves a progressively increasing eccentricity of the rubber sleeves, which gives the rising stiffness characteristic. The diagonal turn-buckle of each link is for setting axle height and compensation for initial creep only ; once the axle is set and the height stabilised it can remain in the same position.

Substantial mileages have been built up without trouble by many vehicles of the Birmingham and Midland Motor Omnibus Company, which have been in service for over five years with the rear suspension, and over two years with both front and rear suspension. The main advantages claimed are reduction of the weight, particularly the unsprung weight, reduced roll because of the wider spring base at the front and at the rear, and elimination of noise, all factors contributing to greater passenger comfort. There is no doubt that, compared to the conventional leaf spring, the rubber suspension constitutes a major advance ; on the other hand, it might appear that many of the advantages claimed in favour of this suspension might also be achieved by coil spring or torsion bar arrangements and, as far as the rear suspension is concerned, probably with less constructional effort.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

FRENCH LOCOMOTIVE EXPERIENCES

SIR,—Replying to Mr. Clayton's letter regarding the above in your issue of September 14th, my remark that "very seldom is any real effort made to recover time" by British drivers is admittedly somewhat too sweeping, but only in the matter of degree. What I meant to have said, and to draw attention to, was that time recovery is certainly not attempted to anything like the same extent in Britain as in France, for which there are two main reasons: (1) in the latter country there is a bonus for time recovery, which is in itself a big incentive, well worth the driver's while to attempt; and (2) there is a Flaman recorder on every French engine, which is studied at the conclusion of the run, and if it shows that time has been lost *en route*, and has not been recovered, the authorities want to know why; if no satisfactory explanation is forthcoming the driver is "for it." Both incentives are as they should be, acting as spurs to effort.

It is by no means the case that French drivers object to the telltale Flaman—on the contrary, they object to taking an engine out if the recorder is not functioning, as it guarantees them against false accusations of slackness or indifference. The record is there in black and white, for all to see. In fact, I think I am right in saying a driver can refuse to take an engine out if the Flaman is *hors de combat*—and that he often does—or even perhaps will not.

The above incentives and records are, of course, not found in Britain, so conditions in the two countries are quite different. Time-keeping is in my experience, totally different, in Britain and France; in the former, trains are often late, as we all know; in the latter they practically never are, at any rate when arriving at the termini. Of the scores of trains I took record of in France, as the "Experiences" show, only one was a minute or two late into Paris, and that was a local, the delay being due to platform occupation. I admit at once that there is excuse for much of the lateness in Britain, as traffic is apt to be far heavier than in France, and junctions more frequent, bringing more interconnecting trains and timetables, but I need not enlarge on this—I only wish to underline the good effect of bonuses and Flamans. I never noticed that the French drivers reacted "dramatically"—merely with common sense! They bear in mind the bonus and particularly the Flaman—"or else"!

There was an error in the account of the Paris/Havre runs, in the issue of August 17th. The weight of the train on which I left France was given as 800 tons gross—say, 770 tons net. I see from my rough and very scrawly notes the latter figures were evidently meant to be 670, making the gross load 700. But even this is a very heavy load for an old engine with only 55 tons adhesion weight, yet despite this—but the record is in the article, and speaks for itself.

I have had a courteous and interesting letter from Monsieur Chapelon, with further facts and figures, which I will, with your permission, refer to, when I have digested them, in a further letter.

I am sorry—*vide* Mr. van Riemsdijk's letter in the September 14th issue—not having included the photograph he refers to—I wrote the article in Victoria, B.C., and had no print available. But I think the illustrations that were given make the rebuilding of the ex-Paris-Orleans engines fairly graphic. I remind your correspondent of the notice on the wall of the Wild West Dance Hall—"Don't shoot the pianist—he is doing his best." So was I.

EDWARD H. LIVESAY

Sheffield, September 30th.

SIR,—I have greatly enjoyed reading the recent series of articles on "French Locomotive Experiences," by Mr. E. H. Livesay.

In several of these articles he refers to the low factor of adhesion found with certain types of French locomotives. In particular, the 2–10–2 compound freight engines, with a tractive effort of 49,470 lb, have an adhesion factor of only 3·09. Mr. Livesay then says that perhaps the tractive effort is only an ideal which it is not intended to reach.

It is perhaps not always realised that tractive effort is only intended to represent the maximum output of the locomotive at very low speeds. By the time speed has reached 10–15 m.p.h. tractive effort will have fallen off by about 25 per cent, and by 25–35 m.p.h. it will have dropped to half.

In the case of this particular locomotive I estimate that at 10 m.p.h. the tractive effort would have fallen to 37,000 lb, giving an adhesion factor of 4·1, and by 25 m.p.h. the tractive effort would be no more than 25,000 lb, with adhesion factor 6·2. Consequently when starting from rest, or travelling at low speeds the driver would have to exercise a certain amount of skill in order to avoid slipping, but once the speed had reached 10 m.p.h. the driver could safely open the regulator to the maximum extent. A similar situation occurs with many modern types of British locomotive, and it has often been noticed that some of these do have an unfortunate tendency towards slipping. Many French locomotives seem to have rather a high proportion of their weight not available for adhesion, and require handling with skill at slow speeds. The fact that they receive such skill is borne out by their clean starts from stops.

Although a locomotive with low adhesion factor cannot use its full tractive effort at low speeds, the extra power is most useful at high speeds, when slipping is not likely to occur for the reasons already given.

W. D. SPENCER

Welwyn Garden City, September 25th.

Literature

The History and Development of Motor Cycles: Part I, Historical Survey. By C. F. CAUNTER. H.M. Stationery Office. Price 4s

SINCE this historical survey is intended as an introduction to the story of the motor cycle, as portrayed by our National Motor Cycle Collection, it is the more noticeable that, excepting for Alfred Scott, all the great innovators in this rich and varied record of engineering endeavour came from abroad. Only the Yorkshireman stands with the Michaux brothers, builders of the first motorised cycle, with the enterprising Comte de Dion, pioneer of the high-speed engine, with the Werner brothers who introduced the light and simple belt-driven machine, with Kelecom, designer of the 1905 F.N. with its four-cylinder engine, shaft drive and internal expanding rear brake, or with Neracher, originator of the monocar.

In Great Britain competent and conscientious mechanical engineers took the crude ideas and engines of Europe and—spurred by the appearance at a hill-climb in 1908 of the Scott, with its three-dimensional frame, all-chain two-speed drive with steel-on-steel clutches, and telescopic forks, and the domination of the first Senior T.T. on the Mountain course, in 1911, by Indian twins with plate clutches and countershaft gears—improved them rapidly.

All the virtues the mechanical engineer can endow were implicit in the British machines when they attained a world supremacy after the first world war. The 1930s are a well-remembered Golden Age of motor cycling: the purchaser could have his machine any colour he liked, so long as he liked black; and with any engine he liked, so long as he liked the camshafts overhead and shaft driven, or the cylinder head bronze with full-radial valves, or a geared crankshaft o.h.c. square four, or a compact side valve narrow-angle V-twin, or a water-cooled two-stroke with two—or even three—cylinders in line. What a contrast from to-day, when one of the sporting camshafts survives, an o.h.c. twin has evolved without hemispherical combustion chambers, eight pushrods have replaced sprockets and chain in the square four, and there is one advanced side valve twin with, strangely, a selective gear change, standing among a multitude of badly silenced two strokes and unbalanced pushrod four strokes, but when there is ample scope for a sophisticated judge of colour, and the same power unit is available in perhaps half-a-dozen marques!

It is not the mechanical engineer who has failed: he has rendered the starting foolproof, and developed light alloy chromed bores that can stand limitless hard driving. He has relegated the "speed wobble" to books such as this, and made the spring frame an asset rather than a liability when corners are being taken fast. But it is now no longer enough to build a bicycle with a motor, however refined the engine or inflexible the frame. It has become necessary to design the machine with its rider on it. But a study of any showroom is evidence that the British motor cycle is still designed—or "styled"—without, even as it appears in the catalogue.

So brief was the British essay at this new

concept of a motor cycle that it can be recapitulated here. The attempt to give the rider the protection that the chains and the magneto had long enjoyed was made, logically enough, by Vincent, whose 998 c.c. V-twins were all capable of sustained speeds over 100 m.p.h. However, the width of the duplex chain primary drive and the centrifugally loaded clutch resulted in the rider having his feet wide apart and therefore sitting high up, and this made the problem of protecting him severe. Presumably because of the available experience with windscreens fixed to the handlebars, which many owners had found desirable to allow their throttles to be opened, the front panels of the enclosed Vincents were arranged to steer with the front wheel. Discreetly, the designer concentrated the panel area across the axis of the steering head, and the resulting machine had a markedly bluff body. Nor could the weather protection be extensive : the bars are as short as on all machines with high-speed handling ability, but it would not readily be ridden without gauntlets. Below the steering head engine cooling dictated the fairing shape, and the flared air intake barely screened the rider's legs.

The " Black Prince " and " Black Knight " appeared at the Motor Cycle Show in 1954. The next year the manufacturer found that his output of motor-cycles, 499 c.c. and 998 c.c., did not justify the existence of a production line, and the " Fastest Standard Motorcycle " abdicated. Why was this attempt to advance the state of the art abortive ? To a certain extent the machine may have been at fault : the design was closely based on previous models, but a frame articulated behind the gearbox with a dual-seat spanning the pivot was replaced with one in which the saddle was fixed to the frame as part of the rear wheel enclosure. A machine designed from scratch might well have been more successful. But unassailable benefits, in the shape of reduced fuel consumptions, were returned by owners, and to-day Vincents are seen with faired headlights and windscreens both for touring and racing. It seems more likely that the restricted demand for machines of this character, and perhaps their long replacement life, forced the development costs to be concentrated on relatively few machines. There was a 499 c.c. streamliner, but, like the conservative machine, it sold at a considerably higher price than other touring five-hundreds.

It is to racing, of course, that we should expect to look for leadership, even as with suspension and braking systems. While record-breaking machines had early grown fairings behind the rider, the fact that motor-cycles, unlike cars, must sacrifice directional aerodynamic stability to maintain lateral dynamic stability caused racing motor-cycles to concentrate on improved forms of entry. Appropriately enough, the supreme example of British motor-cycle engineering, the " Manx " Norton engine that was designed by Carroll in 1930 and developed by Craig to unassailable eminence and a peak of 53 h.p. at 6800 r.p.m., with a compression ratio of 10 : 1 on 90 octane fuel, sustained for ten minutes in a 60 m.p.h. cooling air stream (the performance attributed by Mr. Caunter to the 1939 engine is notably greater than the maker's claims for 42 h.p. on 50-30 petrol-benzole, despite their higher compression ratio of 8·5) was matched with a functional rather than a traditional cycle. The fuel was not in a saddle tank, but in two panniers low down in the centre of the machine, and the rider was prone above them, with the " double knocker " steeply inclined below him.

But the industry generally was not ready to face the problems of a new technology, and Norton, now part of Associated Motor Cycles, adopted a policy of racing only machines that could potentially be sold to private owners. And 1955 saw the first defeat of the " Manx " in the Senior T.T. since 1939, the four-cylinder Gilera and the streamlined Guzzi proving fast enough to discount the " Featherbed's " advantage in cornering, even on the Mountain circuit, on a dry, fine day. At the end of that season the single reasserted itself by proving faster than the four, handled by the then world champion, round an aerodrome circuit. But the mechanical engineer, denied the assistance of the aerodynamicist, cannot expect to engage in unrestricted competition, and 1956 again saw the Senior Trophy go abroad, and only the Team Prize taken by Norton. Meanwhile, the restricted pace of development on the " double knocker " has starved its stable companion, the " International," of advance, and even in the Nine Hours Race at Thuxton it has failed to match the performance of push-rod engines. Now this most honoured of road-going machines is made only in token quantities.

Thus, we see that, while the engineering ability is unquestioned—the twenty-four-hour race for the Bol d'Or has never seen other than a Norton victory in seven years—the British motor-cycle industry seems to show now less enterprise than in the past. Even before World War II Mr. Caunter sees the more progressive outlook of the Continental manufacturers threatening our supremacy. He is, however, in our view, inclined to under-value mechanical refinement : he is tolerant of the unbalanced parallel twin four-stroke, and even looks for the future to the Lancia-style narrow-angle vee-four rather than the geared crankshaft engine with complete primary balance. This may be because the racing twin Velocette is not recorded.

There are certain other matters on which we are forced to differ from the author. The World War II " Matchless " engines were surely not side-valve, but the commonplace push-rod pattern, and was the " Big Four " Norton Model I of 596 c.c. before 1948 ? Confusion appears sometimes between Phelon and Moore and their " Panther " motor-cycles, while the single-camshaft " TRW " Triumph deserves, in our view, to be considered as a more modern design than the " Speed Twin." Criticism may also be made of the facts that tricycles and quadricycles are ignored from 1904 onward, and the index contains only one entry—" Tyres " —other than proper names. Nevertheless, this inexpensive booklet is a valuable compact reference to the subject, the more valuable since there are so few recent works mentioned in the bibliography. Numerous small but clear photographs are included, the majority of them showing exhibits in the Collection. We hope that that collection will soon be enriched with that one British engine that stood against the onslaught of the world in open competition, and whose piston alone is the epitome of the development process.

The Theory of Prestressed Concrete Design ; Statically Determinate Structures. By HENRY J. COWAN. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 36s.

THIS book adds to a trickle, likely in the future to become a flood, of books on prestressed concrete. The first two words of its title set the style and presentation of this work. It adheres to the fairly familiar pattern developed in other books on this subject, i.e. a short historical note followed by a description of the methods employed, followed in turn by a chapter on the properties of the materials used. From this point it attempts to develop the theory of design and gives worked examples to illustrate the various points made. Before trying to review this part of the book attention must be drawn to the chapter on losses. If the losses calculated in the worked examples can be taken as approximately correct for other examples, there must be something fundamentally wrong, since the losses are far less than have been found in practice. The dismissal, too, of relaxation of steel is dangerous and some published research work in this field appears to have been ignored.

The attempt to integrate theory and practice in design, which forms the major portion of the book, has not proved very successful. Only a few points can be referred to. For the design of members with both pre-tensioned and post-tensioned wires the method originally adopted by the late Professor Magnel is expounded, but this has not been used by designers for many years. In the chapter on bond and anchorage a return is made to an old theory originally given by Hoyer, but as far as we know this has not given good correlation with practice and has been abandoned. Unfortunately, probably because of the delay between writing and publication, extensive practical measurements of the transmission length have not been quoted, so that the figures given in the book should be treated with reserve. For the design of end blocks Guyon's method is advocated and the latter's table of constants is given. Here, perhaps, an opportunity has been missed since this is one part of the field where further theoretical work would be welcome. Deflections of prestressed beams are dealt with in the normal way ; but here, once again, in a book essentially dealing with theory an opportunity is missed to develop the theory for the progressive increase in camber of shallow beams where normal theory indicates a decrease. In the chapter on torsion and shear the author usefully brings together his research work on those subjects. A long chapter is devoted to ultimate theory. It has academic interest. But it does not seem to advance one on the road—a road which (it was thought) had finally emerged from the jungle of theory at the last international conference on prestressed concrete.

To sum up, this excellently produced book which has the rather surprising claim on the cover that " it is the first comprehensive work in the English language on the mathematical theory of prestressed concrete structures "—must one excuse publishers for making such claims ?—leaves much to be desired. It offers little or no help to the designer, and, in fact, it might put him off attempting to design in what, after all, is probably one of the simplest materials to design in.

Books Received

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Obituary

SIR RICHARD FAIREY

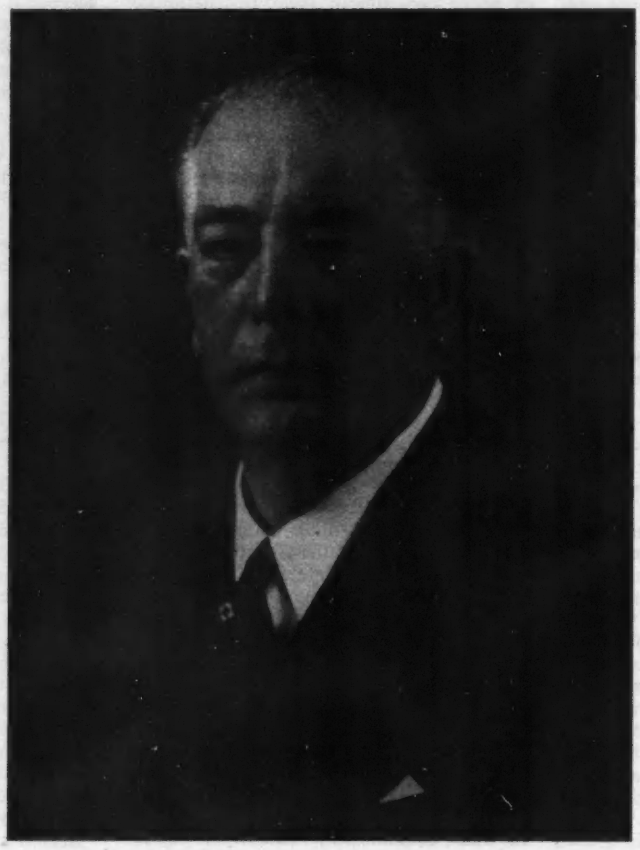
On Sunday last, Sir Richard Fairey died in a nursing home several hours after an operation.

Charles Richard Fairey was born at Hendon in 1887, attended the Merchant Taylor's School, and trained as an electrical engineer at Finsbury Technical College. In the early years of this century he took an active interest in model aircraft, with which he was highly successful in competitions. In 1911 he became chief engineer of the Blair Atholl Syndicate, formed by J. W. Dunne to build his stable aeroplanes, and two years later took a similar post with Short Brothers, who were also building aeroplanes at Eastchurch, Isle of Sheppey. When the Fairey Aviation Company, Ltd., was founded in 1915, the first aircraft it built were Short seaplanes for the Admiralty. At that time the Royal Flying Corps was equipped principally with aircraft originating from the Royal Aircraft Factory, and so the company concentrated on machines for the Royal Naval Air Service. The first Fairey design was a large twin-engine biplane, the "F.2," remarkable for its folding wings. This did not go beyond the prototype stage, but it was followed by a contrasting design of great interest. To meet a naval requirement for a seaplane needing only small stowage space, Fairey adapted the Sopwith "Baby," and, to obtain an acceptable landing speed, made provision for the camber of the wing to be varied, the rear part of the wing being hinged at the rear spar. This and other devices to ease the design compromise between high and low-speed cases were long a characteristic of Fairey aircraft. At the end of the war were initiated the versatile "III" series and two large flying-boats, "Atalanta" and "Titania."

The intense advance in performance that had taken place during the war did not continue in the subsequent years. When Fairey secured the British rights to the Curtiss "D.12" liquid-cooled V-12 engine and the Reed metal airscrew—one engine he brought back from the U.S.A. in his own cabin aboard ship—he was able to build a two-seater day bomber, the "Fox," which exceeded the performance of contemporary bombers by about 50 m.p.h. At Northolt aerodrome one took the air with an Armstrong Whitworth "Siskin" fighter and proved able to carry the battle to the single-seater. Subsequently, one squadron of the Royal Air Force was equipped with these very clean single-bay biplanes. Later the type was sold overseas, and was built by the Fairey subsidiary in Belgium.

Aerodynamic refinement was also the essence of another successful design, the Long Range Monoplane. A thick cantilever wing housed 1000 gallons of fuel, and a slender fuselage, the Napier "Lion" broad-arrow twelve and a crew of two; in a flight of nearly fifty-seven and a half hours, the Mk. II aircraft established a world record for distance flown in a straight line of 5309 miles.

It was an ambition of Richard Fairey's to build a complete aircraft—airframe, engine and propeller—and Captain A. G. Forsyth designed for his firm a supercharged V-12, the "Prince." No support was forthcoming for this engine, which compared with the Rolls-Royce engines that had followed the imported "D.12's," and so a highly original project was undertaken. This was an H-24, in which each side of the engine was completely independent and drove its own half of a contra-rotating propeller; the advantage of this arrangement was that, using it, a naval aircraft with folding wings could incorporate twin engines. This engine, with two-speed superchargers, developed 2200 h.p. and weighed 2200 lb; a variant, which was not actually flown, had a second supercharger for each bank, making four in all, which could be clutched in at high altitude and gave the remarkable performance of 1700 h.p. at 40,000ft. At the commencement of the 1939-45 war, the "P.24" engines and designs were taken to the U.S.A., where the Ford Motor Company initiated production for use in the Republic "P.47" fighter; when the U.S. also entered the war, this advanced project was finally abandoned and the "Thunderbolt" appeared with a turbo-charged air-cooled radial.



Sir Richard Fairey

Meanwhile, the Fairey aircraft had developed rapidly, numerous projects having included the fabulously beautiful "Fantôme" biplane and the less prepossessing "Hendon" night and "Battle" day bombers. When the war began, pressurised four-engined airliners were being built for British Airways. Fairey equipment was still prominent in the Fleet Air Arm, the "Seal" having been followed by the "Swordfish," and during the late war this arm again became the speciality of the company with their "Fulmar" fighter, "Barracuda" torpedo-bomber, and "Firefly" fighter reconnaissance two-seater.

After the war, the twin-engine naval aircraft was brought to actuality in the "Gannet" with an Armstrong Siddeley "Double Mamba" driving independent contra-props. The company now diversified its activities greatly: a helicopter, the "Gyrodyne," was built which established a world speed record at 124 m.p.h. Subsequently, a study of the Doblehoff helicopter project in Austria led to the adoption of reaction propulsion for the rotor, compressed air being delivered along the blades to burners at the tips: unlike Doblehoff, Fairey mixed in the fuel only at the combustion chamber. The airscrews, being no longer required to react torque, were now free to drive the machine forward, and another step towards the conventional aerodyne was to incorporate a fixed wing. These principles are now being built into the "Rotodyne" transport, which exploits the ability of the tip-jet motor to liberate really high powers, in this case around 7000 h.p. An entirely different vertical-take-off project was the Fairey "Delta I," which it was intended to control under powered lift by pivoted jets at the rear of the fuselage. Vertical ascents were made by models, but the piloted aircraft flew only on aerodynamic lift. Another research aircraft, the "Delta II," became world-famous this year when it established a speed record of 1132 m.p.h.: with 60 deg. of sweep on the leading edge, it exceeds Mach number 1·8 with a single after-burning turbine. Supersonic aerodynamics is also exploited by the guided weapons division of the company, which has produced the "Fireflash" missile. At the same time, the company has carried out interesting work on power controls, production methods, and full-scale lofting.

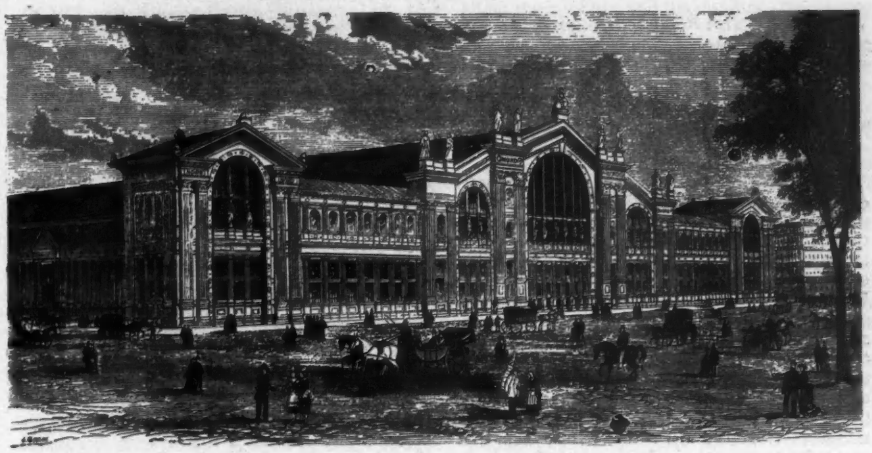
During the second war Fairey himself was not working with his company, but was in the U.S.A. where he became head of the British Purchasing Commission: in 1942 he was knighted.

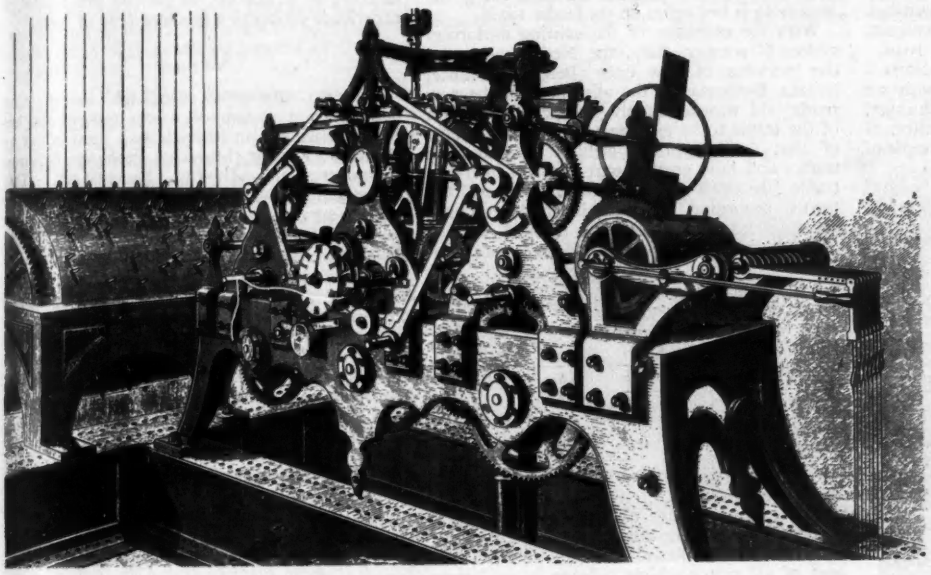
He had many interests besides aviation. He sailed his yacht "Flica" in 12m races and, when the big "J" class was active, raced the "Shamrock V." Subsequently, he took part in the design of another 12m, the "Evaine." For many years he had a Stanley steam car. He was an ardent fisherman, and held a stretch of the River Test.

Sir Richard was an Honorary Fellow of the Royal Aeronantical Society and of the Institute of the Aeronautical Sciences; he had been president of the R.Ae.S. and chairman of the Society of British Aircraft Constructors. He was a member of the Order of the British Empire, a Commandeur de l'Ordre de la Couronne, and held the United States Medal of Freedom with Silver Palm. He is survived by his second wife, two sons, one of whom, Richard, is on the board of his company, and a daughter.

ENGRAVINGS OF 1876

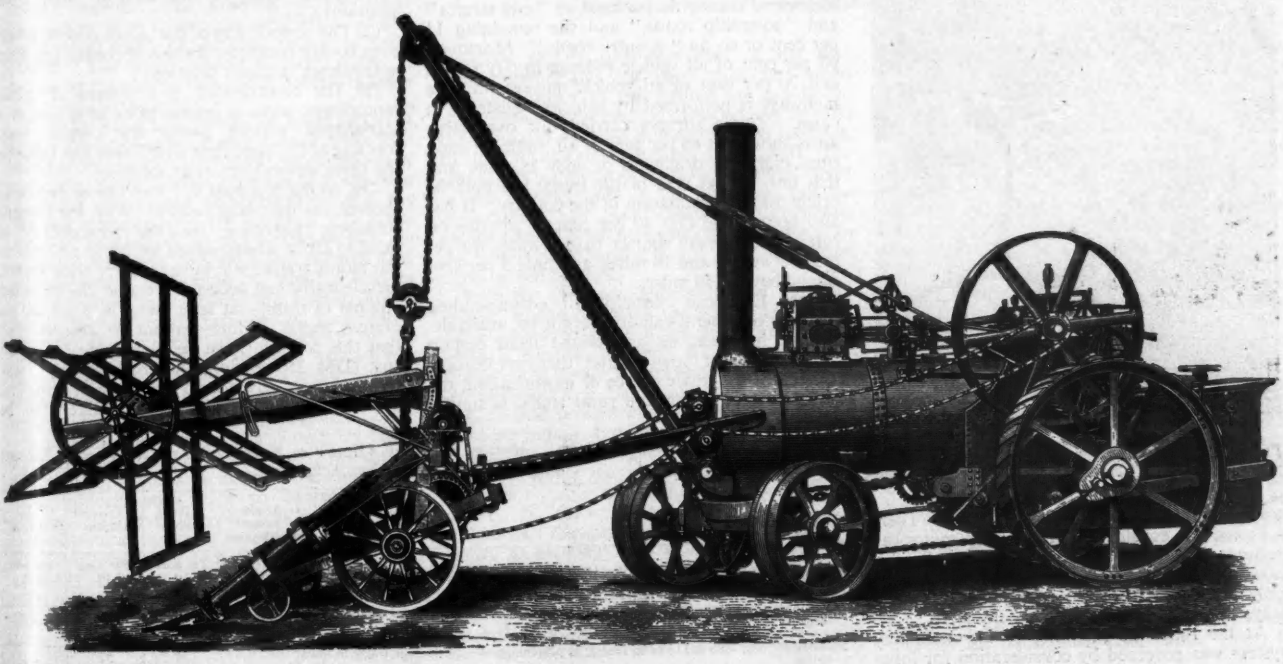
The right-hand engraving illustrates the Paris terminus of the Chemin de Fer du Nord. It is reproduced from our issue of August 4, 1876. A description of it says that "this magnificent station was erected between the years 1861 and 1864. The area occupied by the entire station is about 9 statute acres. The great central hall for the arrival and departure of trains is covered in by a roof of great magnitude, and remarkable alike for the originality, simplicity and beauty of its design. The covering of the roof consists of two plane surfaces meeting each other at the ridge, and making a much smaller angle than usual with the horizon. The entire span of the roof is nearly 230ft, unbroken by any supports except two columns beneath each principal rafter."





The turret clock for Bombay University, which is shown by the left-hand engraving, was constructed by Smith and Sons, Clerkenwell, and described in our issue of December 8, 1876. It was a musical and chiming clock, designed to show the time on four illuminated dials, 12ft 6in in diameter. But these dials, we commented, were "a great deal too small considering the elevation of the clock above the ground."

The steam reaping machine, illustrated in the engraving below, was built by Aveling and Porter, Rochester, and described in our issue of September 1, 1876. Our article says: "the arrangement in principle is very simple. Mr. Aveling has taken one of his 8 h.p. steam crane traction engines and coupled it on to a Crosskill reaping machine. The knife reciprocates at the foot of the inclined platform, a crank under the platform communicating motion to it. The machine is carried on four wheels, two small ones in front, and two much larger, of wood, behind."



Urban Motor Roads

No. II—(*Concluded from page 442, September 28th*)

The British Road Federation held a conference on urban motorways at the Friends' House, Euston Road, London, on September 18th to 20th. The problems before the conference were discussed in a leading article last week, when a résumé of part of the conference proceedings, with emphasis on the analysis of London's traffic, was also given. Here we conclude our account of the conference, with some notes on European urban motor roads.

A REVIEW of urban motor road proposals in many of the principal European cities was given in the paper discussed at the conference on the morning of Thursday, September 20th, namely, "Some Aspects of Planning and Design of Urban Motorways," by Dr.-Ing. H. M. Feuchtinger. The conference also discussed a considerable number of supplementary papers, submitted as written contributions to the discussion on urban motorway practice, and grouped under the two general headings of United States and European contributions. The authors of these papers were, generally speaking, the engineers responsible for the highways of the particular town or region with which they dealt, so that an authoritative collection of opinions on contemporary ideas of urban motorway development is to be found in their writings. Engineering considerations were prominent, but other aspects of the urban motor road—town planning and legal and financial matters—were also explained. We conclude with an abstract from the paper by Dr.-Ing. Feuchtinger, from which we have selected his description of the Munich motor road system as an example of plans for a European city.

Motorways and Towns

In Europe, the first motorways with separate carriageways, grade separation and full control of access were built in Germany and the Netherlands in the 1930s. Their predecessors, the Italian autostrade, still lacked the criterion of traffic separation for opposite directions. There followed the construction of isolated motorway sections in other European countries. So far, however, Germany and the Netherlands are the only countries that have a real system of motorways.

Proposed Munich motorway system. Model of "star solution" between Central Station and Theresienwiese

At the time, the planning of the motorway system was governed by consideration for long-distance traffic. The motorways were thus deliberately designed as arterial highways for long-distance communications. Their general alignment was intended to be as straight as possible, and was not to be affected by intermediate traffic objectives such as towns.

This conception automatically entailed a certain relationship between motorway and town inasmuch as the motorways made contact with towns outside built-up areas. Connection with the city was provided by feeder roads which were, in most cases, existing highways or urban streets with mixed traffic. Even up to the present, in many cases it has been impossible to redesign these feeder roads for a capacity adequate for their purpose. In consequence, much of the time gained through using the motorway is lost again on the feeder roads.

With the extension of the existing motorway system (Germany, Italy, the Netherlands) and the planning of new ones (Belgium, France, Britain, Switzerland), the alignment of the new roads will depend largely on the composition of the traffic to be expected. How great a part of that traffic will be genuine long-distance traffic, and how great a part regional inter-city traffic ? In other words, to what extent will the towns, according to their size and structure, generate and attract motorway traffic ?

The United States, where traffic is almost completely motorised, are about twenty-five years ahead of road traffic developments in Europe. There it has been found that only about 50 per cent of all motor-vehicle mileage is on "state highways," nearly 40 per cent on "city streets" and "township roads," and the remaining 11 per cent or so on "country roads." Moreover, 90 per cent of all vehicle mileage in city streets and 70 per cent of all vehicle mileage on state highways is performed by vehicles registered in cities. Traffic surveys carried out over large areas show that 86 per cent of all traffic on main rural highways originates or ends in cities, and that only 14 per cent of the traffic has both its origin and its destination in the country. It has also been found that 40 per cent of all trips on rural highways are shorter than 5 miles, 25 per cent between 5 and 10 miles, and only 5 per cent extend beyond 50 miles.

For European conditions, corresponding statistics of general validity are not yet available. It can, however, be ascertained from certain observations of road traffic that in Europe, in spite of the lesser degree of motorisation, the proportion of urban and rural traffic is similar to that in the United States. There is, for instance, remarkable agreement between representative American statistics and European survey results in respect of the proportion of through traffic contained in the total inbound traffic of a town, as a function of the size of the town. In both cases the proportion of long-distance traffic decreases as the size of the town increases.

This points to the fact that the larger the town, the less can its urban traffic problems be solved by motorways or other by-pass roads such as ring roads, &c., by-passing the town in a wide arc. A further example of the similarity of the proportions of urban and rural traffic in the United States and Europe respectively is provided by surveys of distances covered by daily traffic entering cities. In Düsseldorf, Munich and Vienna, where about 50 to 55 per cent of the vehicles cover distances of about 12½ to 15½ miles, curves showing the incidence of the different distances as a percentage of the total number of vehicles entering the city do not differ, in principle, from a corresponding curve representing conditions on American roads.

Because of this remarkable similarity in road traffic trends in the United States and Europe, it is justifiable to base discussion of planning aspects of urban motorways in Europe on development in the United States, all the more so as there is in Europe, as yet, no great pool of experience concerning this new type of road.

Munich

Hitherto the most thorough investigation concerning a system of urban motorways has been carried out in Munich as a joint effort by Professor Rucker (Munich), Professor Schlums (Hanover), and Dr.-Ing. Feuchtinger. This investigation, which was based on extensive traffic surveys, covered the following three solutions for linking the three autobahnen from Salzburg, Stuttgart and Nuremberg which at present end at the fringe of Munich's built-up area :—

(1) The construction of a ring of motorways around the edge of the built-up area (ring solution) ;

(2) The remodelling of the urban streets, which even to-day constitute the links between the three autobahnen (tangent solution) ;

(3) The construction of a system of urban motorways, without intersections at grade, in a star-shaped pattern across the central area, forming at the same time an efficient link between the three autobahnen (star solution).

The traffic forecasts for these three solutions showed the following results. With the tangent solutions, providing for the remodelling of existing urban streets, which would, in addition to the motor traffic, still have to carry tram traffic, bicycle traffic and pedestrian traffic, the expected volume of traffic—at least twice as great as the present traffic volume—cannot be absorbed, so that this solution must be discarded. At equal cost (DM 250 million) the roads of the "star solution" are expected to attract nearly two and a half times the traffic volume likely to be

TABLE I—*Munich Motorway System. Mean Traffic Volume with Each of the Three Solutions. Number of Passenger Cars Per Sixteen Hours, Based on 1952 Traffic Volume.*

Solution	One-way			Total traffic both ways	Standardised for solution (1)
	External traffic	Internal traffic	Total traffic		
"Ring solution"	1,930	1,803	3,733	7,466	1·00
"Tangent solution"... ...	1,810	5,303	7,113	14,226	1·91
"Star solution"	3,000	5,309	8,309	16,618	2·23

TABLE II—*Munich Motorway System. Measure of Relief Afforded to Town Centre by Removal of Through Traffic for Each of the Three Solutions.*

	Under present conditions	"Ring solution"	"Tangent solution"	"Star solution"
External traffic not starting or ending in town centre, as percentage of total through traffic in town centre	Per cent 36	Per cent 10	Per cent 19	Per cent 1
Internal traffic not starting or ending in town centre, as percentage of total through traffic in town centre	64	56	24	17
Measure of relief afforded to town centre, as percentage of total through traffic in town centre	—	34	37	82

attracted to the autobahnen of the "ring solution" (Table I). With a general traffic increase to twice its present volume, only one-third of the capacity of the four-lane autobahn ring would be utilised. In contrast, the roads of the "star solution" which will have six lanes in the centre and four lanes on the outlying sections, would be utilised to 80–90 per cent of their capacity.* Accordingly the measure of relief afforded to inner urban traffic is by far the greatest with the "star solution" (Table II). Owing to proximity of the motorways to the town centre (the illustration shows the section between the Central Station and Theresienwiese), almost the entire traffic (82 per cent of it) not originating or ending in the city centre itself will be removed from the urban streets, which will thus be enabled to cope with the expected increase of the city-bound traffic.

The City Council has decided to embody the "star solution" in the master plan. This decision has been decisively influenced by the traffic study, the cost of which amounted to DM 250,000 (i.e. 0·1 per cent of the construction costs of the scheme), including DM 100,000 for traffic counts alone. The study has brought quantitative proof that it is possible to apply successfully in European cities the basic principle of urban motorways linked to long-distance motorways. In each individual case, however, a point should be made of carrying out, as a first planning measure, an investigation of the kind carried out in Munich in order to ascertain the traffic value and economic impacts of the new highway system.

The Ruhr Expressway

The first major urban motorway project to be actually realised is the Ruhr Expressway, which connects the chain of Ruhr cities from Duisburg to Dortmund, and which has been under construction since 1954. Over its length of about 30 miles the expressway represents in fact a chain of urban motorways. The existing federal highway, with intersections at grade, carries some 15,000 to 20,000 motor vehicles per day, which is some of the heaviest traffic on any three-lane road in Germany. The new cross-section provides for dual carriageways with two lanes each. The adjacent bicycle tracks can later be reconstructed as shoulders. Most of the intersections are either flyovers or underpasses. Where this was not possible, vehicle-controlled traffic signals have been provided. One section between Essen and Bochum is already in operation.

The construction of the entire Ruhr Expressway is scheduled to extend over ten years and to cost more than DM 100 million. The road crosses right through the town centres; for example, it crosses Essen in a tunnel of half a mile length in the immediate vicinity of the railway station. The function of the Ruhr Expressway is to absorb the originating, ending and internal traffic of the great industrial Ruhr district. The long-distance through traffic is carried by the autobahnen, which form a triangle of tangents to the area.

Plans are afoot to promote the construction of similar inter-city expressways in other areas with strong economic ties and heavy concentrations of traffic, e.g. a Rhine-Main expressway in the area of Mainz, Wiesbaden and Frankfurt, and the Emscher expressway in the north of the Ruhr.

Urban motorways should not, however, be promoted for their own sake and because they are becoming "fashionable." What should be done is to base each scheme on a detailed traffic study, which must provide a quantitative measure of the need and suitability of the scheme. The examples of Brussels, Munich and Stockholm show that it is quite possible to carry out reliable surveys of this kind with the means at present at the disposal of traffic engineers.

It is from these angles that London's traffic problem, too, should be regarded and approached, although its solution is likely to be among the most difficult tasks ever to confront traffic experts. But in London as well as in all other European cities suffering from traffic congestion it is worth tackling this problem with all the available resources of modern technique, for our cities want to live, and only if they live can our economic life flourish.

* Total traffic expected on the various roads is plotted in diagrams in the original paper.

37 B.H.P. Agricultural Tractor

THIS week Massey-Harris-Ferguson, Ltd., has introduced a new "all-purpose" wheeled tractor, which is to be manufactured at Coventry. It is the "Ferguson 35" and will be available in two models—standard and "de luxe." There are four engine alternatives, petrol, diesel, vaporising oil, or lamp oil, all of them being four-cylinder units. With petrol or diesel engines the tractor is said to give 37 b.h.p., the output of the other two engines being 30 and 29 b.h.p. respectively. Fig. 1 shows the general appearance of the new tractor, the model illustrated being one fitted with the carburetted engine. The diesel engine to be used for the "Ferguson 35" is a new product which presents some interesting design factors, as will be gathered from the following details.

This diesel engine is directly developed from the Standard Motor Company's previous 2-litre unit to give a higher output. Since the same cylinder bore centres had to be used in the engine, only a limited increase in swept volume was possible—the bore has been enlarged from 3 7/16 in to 3 1/16 in to give a capacity of 2260 c.c.—and the most important modifications are found in the cylinder head. The cylinder assembly closely resembles that of the previous version, and the new crankshaft could be incorporated in the smaller engines if the shells of the centre bearing were replaced by ones the same size as those in the other two bearings, to allow for the enlarged fillets on the shaft. The crankshaft is now cross drilled to admit oil closer to the pressure area of the big ends, and the opportunity has been taken to incorporate sludge traps. Interchangeability also extends to the water pump assembly and such short-lived items as the fan belt.

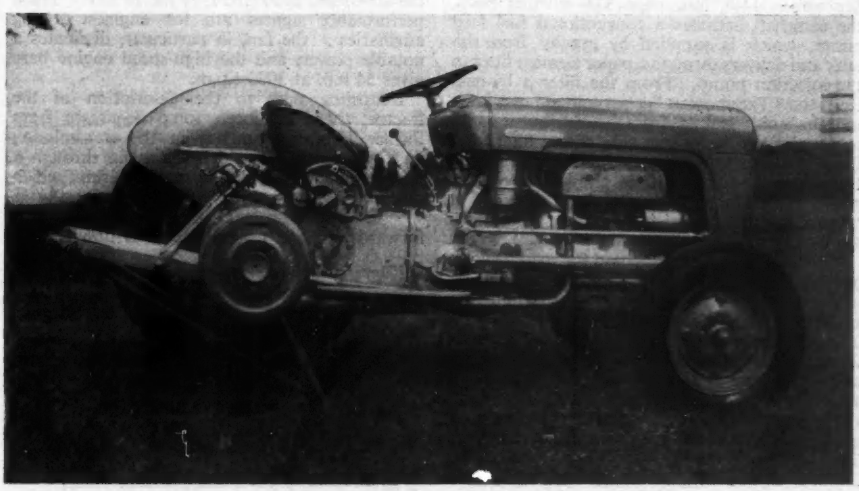


Fig. 1—The tractor is here shown with the carburetted engine of 2186 c.c.

With the Freeman-Sanders head of the 20 C. engine, smoke restricted the output achievable. Development to higher b.m.e.ps. commenced by using a Ricardo "Comet III" chamber, and this gave the higher powers required. A "Comet V" chamber was then tried—one is shown in Fig. 2—and proved less smoky at low revolutions per minute, but more difficult to start. The V chamber was therefore modified to the present form, in which the inserted lower part of the chamber is spherical opposite, but bucket-like above, the throat. The nozzle is a C.A.V. "Pintaux," the spray being directed towards the centre at starting and widening out into the normal pintle pattern at higher revolutions per minute. The injectors are held in place by clamps, which push them axially into position, reducing the risk of misalignment or distortion. As can be seen, the rocker cover has to be recessed to admit the injectors, and the resulting complicated shape is cast in light alloy.

The exhaust valve is free to rotate when open and seats on an insert; the full width of the valve face makes contact with the seat. Since this feature results in the sudden application of the spring load to the stem at every closing, the stem diameter has been increased to nearly ¼in.

In order to avoid the distortion caused by jamming studs into tapped holes, set screws are used to secure the deep iron head casting, except in the holes along the timing side of the engine.

The induction manifold is a light alloy casting and carries a C.A.V. "Thermostart" cold starting aid. This consists of an electrically heated coil to which fuel oil can be supplied under gravity from a small reservoir. When "Heater" is selected before starting, fuel is admitted and ignited as the coil becomes hot. The heater remains in action when the starter is activated, and thus the device results in the inspired air being much above the ambient temperature. With the use of this cold starting aid the starting of the Freeman-Sanders engine can be excelled at low temperatures. The engine is motored by a 12V starter, which is controlled by a solenoid that engages the pinion positively.

The drawing shows the provision made for continuous ventilation of the crankcase; air from the rocker box passes to the induction tract downstream of the air cleaner through a restriction, in which a wire is hung to avoid blockage. In fact, this positive ventilation is replaced on the tractor engine by a pipe opening below the sump; this is because the diesel engine has proved more vulnerable even than a petrol engine to exceedingly fine dust, and it is desired to avoid the risk of such dust entering through the external ventilation pipe. On the ventilated engines an air intake cleaner is fitted to the tappet cover.

Below the steel and copper head gasket slip-fit dry liners are located by deep narrow flanges. The solid skirted pistons carry plain chrome rings in the top groove, tapered rings in the next two, and either a Wellworthy "Duaflex" or a B.H.B. "Cygflex" oil control ring above the gudgeon pin. On the skirt there is a groove for an additional scraper ring, but it has not been found necessary to fit a ring here on any engine up to date. The big end caps are located transversely on the connecting-rods by closely finished overlaps at each end, and axially by a dowel through which the lower retaining bolt passes. The rods are withdrawn up the bores and the crankshaft and bearing assembly through the back of the crank-case. From the

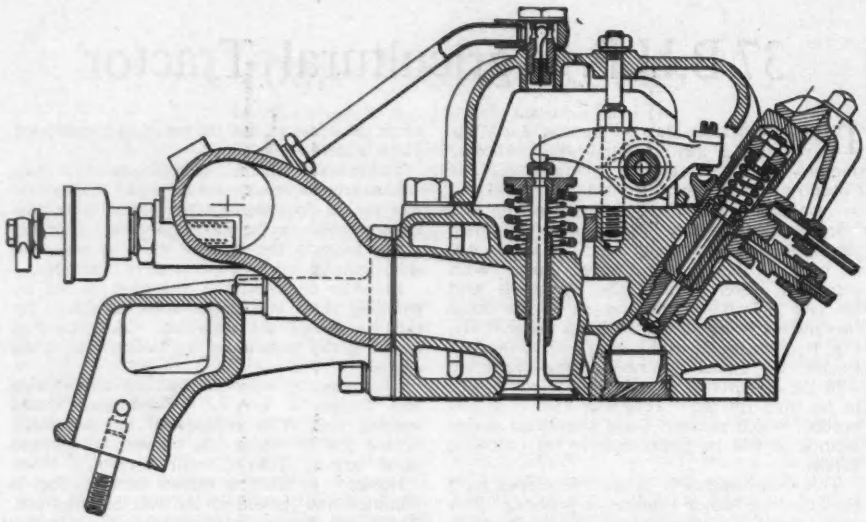


Fig. 2—Cross section of cylinder head of 2260 c.c. diesel engine

front end of the crankshaft a chain tensioned by a hydraulically loaded rubber pad runs to the camshaft. Between numbers one and two cylinders a gear drives, through an idler wheel, a mechanically governed C.A.V. distributor pump such as was described in these columns on September 14th last, page 373. Further back, the camshaft actuates a conventional fuel feed pump, which is supplied by gravity from the tank and delivers through a paper element filter to the injection pump. From the filter a by-pass feeds the "Thermostart" reservoir and overflows into the tank; leakage from the distributor pump is returned to the output side of the filter, and from the injectors direct to the tank. Lubrication is by oil to Mil. L. 2104 A, circulated by a gear pump at 50 lb per square inch through a "Purolator" full-flow filter: the sump holds 12 pints.

This engine is, of course, used for road vehicles as well as tractors. Besides the ventilation arrangements mentioned above, the automotive units differ in their valve and injection timing. The camshaft of the 23 C. gives a valve overlap of 21 deg., while for that of the 23 C.V. the corresponding figure is 26 deg. Injection commences 16 deg. b.t.d.c. on the low-speed engine, while the high-speed engine has automatic injection advance from an initial setting of 10 deg. b.t.d.c. The performance curves in Fig. 4 are for the 23 C.V. engine, which has a hydraulic governor set to give 50 h.p. at 3000 r.p.m. This rating is used in commercial vehicles up to 2 tons, but it is anticipated that in the lighter Standard vehicles the engine would be governed to 57 h.p. at 3500 r.p.m. The tractor engine gives 36 h.p. at 2000 r.p.m., and has a 12-hour rating of 26 h.p. at 1800 r.p.m. Both engines have a maximum torque of 1170 lb-in, delivered at 1640 r.p.m. by the 23 C. and 2100 r.p.m. by the 23 C.V. These performance figures are for engines driving auxiliaries: the fan, in particular, dissipates a notable power, and the high-speed engine bare gives 54 h.p. at 3000 r.p.m.

Returning now to the description of the tractor, there has been some departure from former Ferguson practice in the transmission and hydraulics. The drive is taken through a double clutch to a sliding mesh gearbox which provides, by itself, three forward and one reverse speeds. An additional lower range of three forward and one reverse speeds is obtained by taking the drive through a planetary gear unit which effects a reduction of 4 : 1 in all speeds. Thus, there are available six forward speeds, between 1·28 and 14 m.p.h. at 2000 r.p.m., and two reverse speeds of 1·71 and 6·8 m.p.h.

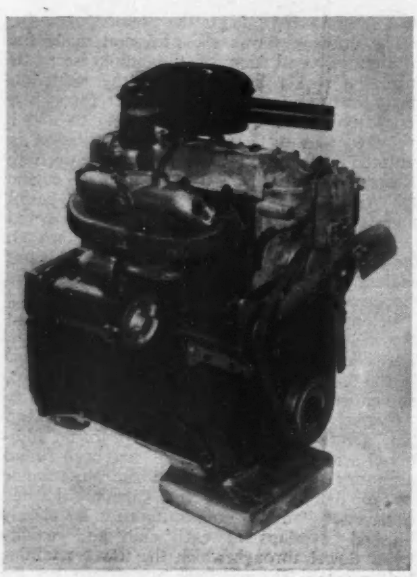


Fig. 3—Vehicle engine showing "Thermostart" and ventilation pipe attached to manifold

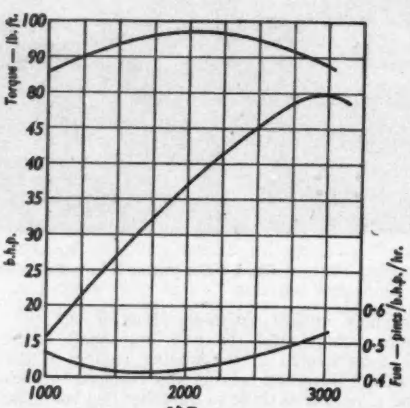


Fig. 4—Performance curves of 23C.V. engine

The secondary clutch disc drives a hollow shaft, from which power is delivered through the tubular gearbox layshaft to the hydraulic pump and power take-off shaft. By means of a sliding coupling the power take-off shaft may be connected to the pump drive shaft to revolve at a speed proportional to that of the engine or, alternatively, to a gear wheel on the main drive pinion shaft to turn at a rate governed by the ground speed of the tractor. On the "de-luxe" tractor, the p.t.o. shaft becomes "live" when coupled to the pump shaft. Initial depression of the clutch pedal disconnects the primary disc and stops the drive to the back wheels, but the p.t.o. shaft continues to rotate until there is a further depression of the clutch pedal which disengages the secondary disc and stops the p.t.o. drive. The power take-off shaft, the rear end of which is 1⅜in diameter, rotates at 450 r.p.m. at an engine speed of 1500 r.p.m., the reduction being 2·78 : 1. The p.t.o. selector lever is placed on the left side of the tractor below the driver's seat.

The hydraulic system is arranged in the centre housing of the tractor. It comprises a four-cylinder pump which supplies oil through a vertical pipe to the hydraulic cylinder at a maximum pressure of 2500 lb per square inch. A connecting-rod from the cylinder engages the ram arm of the lift shaft, the ends of which project from the top of the casing. At each end of the shaft there is an arm to which is attached a lift rod, which is in turn connected to the mid-point of each lower link of the three-point linkage. The right-hand rod is adjustable for length by means of a levelling lever, and implements are attached on rear ball mountings to the lower links, which can pivot on their forward ball mountings at the base of the back axle casing. The arrangement is such that, when oil under pressure from the pump is supplied to the closed end of the hydraulic cylinder, the piston is forced backwards, rocking the lift arm and thereby rotating the lift shaft to raise the lower links. Similarly, when oil is allowed to drain back to the hydraulic system, the piston retracts into the cylinder under the load on the links.

Standard High-Speed Diesel Engine Specifications

No. of cylinders	Four
Capacity	137·89 cu in (2,260 c.c.)
Bore	3⅛in (84·14mm)
Stroke	4in (101·60mm)
Compression ratio	20 to 1
Firing order	1–3–4–2
Fuel injection pressure	1550–1620 lb/in²
Maximum power (net)	50 b.h.p. at 3000 r.p.m.
Maximum torque (net)	97·5 lb-ft
Maximum governed speed	3250 r.p.m.
Maximum piston speed	2185ft/min
Governed idling speed	600–650 r.p.m.
Minimum fuel consumption	0·41 lb/h.p.-hr
Dry weight complete	590 lb (617 lb for low-speed engine)

The tractor's steering mechanism incorporates a recirculating ball unit. The lower end of the steering shaft has helical grooves and rotates on recirculating ball bearings within a specially designed nut. Rotation of the steering wheel and shaft forces the nut to move vertically up or down the shaft and, in doing so, to actuate the left and right-hand steering assemblies. Self-energising, internal expanding double shoe brakes are fitted to the new tractor, the brake drums having a diameter of 14in and a face width of 2in. The two in-line brake pedals are situated on the right-hand side of the transmission, and an interlocking latch is provided to give a single master pedal acting on both rear wheels simultaneously. The tractor styling is the customary Ferguson grey combined with a metallic bronze.

Engine Research

THE thirteenth Annual Report of the British Internal Combustion Engine Research Association, covering the year ended March 31st last, has now been published. The Council, having discarded the possibility of amalgamating with the Motor Industry Research Association, has discussed its intention of increasing income to balance expenditure by March, 1957. Because of the difficulty of recruiting staff, the Council hopes to obtain the services for long periods of research engineers of member firms. No arrangements have yet been made for the manufacture of the Bicera compressor as a pressure charger, and the Association is encouraging the manufacture of high-pressure turbo-chargers. A Paxman V-12 diesel, which is to run so aspirated, has been lent by the makers; it is being converted to run on six cylinders. An interesting result of the work on positive displacement blowers was that a lobe-type compressor with an aftercooler gave an improvement in efficiency as well as 50 per cent more torque on a standard Ruston diesel. Continued development of the hydro-pneumatic fuel injection system showed consistently good results. The progress of the gas turbine was reviewed by a panel of twelve members. The report lists 102 outside members of Council, Committees and Panels, and a staff of seventy-six, including thirteen engaged on research.

International Astronautical Congress

AMONG the societies elected to membership of the International Astronautical Federation at the Seventh International Astronautical Congress, held in Rome from September 15th to 22nd, was the Astronautics Group of the Astronomical Council of the U.S.S.R. Academy of Sciences. This group, which has about twenty-six members and was represented by Professor A. Sedov, was elected as a national member society with full voting rights, although some doubts were expressed as to whether this was permissible under the terms of the I.A.F. Constitution. Two other delegates from this group were expected, but did not arrive.

Over forty technical papers were presented at the Congress; they varied greatly in quality, and in some cases insufficient time was available for adequate presentation and discussion. Probably the more important were those dealing with the Project Vanguard artificial earth satellite programme, forming part of the U.S. contribution to the International Geophysical Year. N. E. Felt, jun., presented a paper on the three-stage launching vehicle, which is believed to be the first large rocket to be flown without fins; stabilisation will be accomplished solely by use of a gimballed engine. John DeNike of the Glenn L. Martin Company, which is the prime contractor for the launching vehicle, discussed the effect of the earth's oblateness and atmosphere on a satellite orbit. Careful observations of the orbit will provide a better picture of the shape of the earth and of the distribution of mass. J. M. J. Kooy, of Holland, also considered the mathematics of satellite perturbations.

While the early observation of the satellite orbits will be by radio tracking, in the later stages of the flight optical methods will have to be employed; they will also be important in the event of a premature radio failure or if some satellites are launched without self-contained radios. Dr. Fred L. Whipple, Director of the Smithsonian Astrophysical Observatory, announced the initiation of the optical tracking programme, under the code name MOONWATCH. The MOONWATCH programme is to be carried out by teams of skilled and reliable amateur astronomers equipped with large binoculars or telescopes, and organised by the national astronautical societies in conjunction with their corresponding IGY committees. The first few satellites are to be launched in orbits lying wholly between the 40 deg. parallels of latitude, so that observers are mainly required in the countries situated within these limits. Subsequent U.S. satellites may be launched in other orbits; the Russian satellites which are to be launched will almost certainly travel in orbits sweeping over a greater region of the earth, so that in this country plans are being made by the British Interplanetary Society to establish teams of MOONWATCH observers at its Harrogate observatory and elsewhere. Before the launching of the first satellite all groups will be screened and trained; periodic bulletins are being issued by Dr. Whipple to indicate the progress of the programme, methods of observation, &c. The data obtained by the groups of voluntary observers throughout the world will be passed to a central computing bureau; H. R. J. Grosch, of the General Electric Company, U.S.A., stated that the electronic computers already available were capable of computing the satellite orbits in a few seconds or minutes. This is desirable, as the orbital period will be only some ninety to one hundred minutes.

J. J. King (U.S.A.) considered the use of the earth satellite vehicle for measuring stratosphere temperatures, and M. Dubin its use in the investigation of interplanetary matter or "cosmic dust." This investigation has been given high priority amongst the experiments to be made as part of the Vanguard project. Further information about the project was given at a press conference held by Lieut-Commander Patricia Grace Conwell, Head of the Public Relations Office of the U.S. Naval Research Department. The construction of twelve launching vehicles has been authorised, and the total cost of the whole project will amount to between 25,000,000 and 28,000,000 dollars. Two quite distinct solid propellant rockets are being developed by the Grand Central Rockets Company, and the Allegheny Ballistics Laboratory respectively; the choice between them will be made at a later stage in the programme. As the satellite will be quite small (about 20in diameter, weighing 21½ lb) special miniaturised instruments smaller than any yet used are being devised. No date has yet been fixed for the launching of the first satellite, since an extensive programme of tests has first to be carried out.

W. B. Klemperer and R. M. L. Baker, jun., of the Douglas Aircraft Company, have investigated the computation of satellite librations (i.e. oscillations about the equilibrium attitude), paying particular attention to dumbbell-shaped and ellipsoidal satellites. Professor S. F. Singer, of the University of Maryland, has continued to work on his MOUSE project, which played a large part in stimulating the establishment of project Vanguard, and did itself evolve out of an earlier design study by three other members of the British Interplanetary Society. Together with D. T. Goldman, Professor Singer has made a study of the radiation equilibrium and temperature of the MOUSE artificial satellite; their results include nomograms of equilibrium temperature suitable for use in satellite design.

The other papers dealing with satellites included a grandiose proposal of the Goodyear Aircraft Company, entitled METEOR (a Manned Earth Satellite Terminal evolving from Earth-to-Orbit ferry Rockets). A detailed report on the proposal was presented by Darrell Romick, of Goodyear's Aerophysics Department, who said that METEOR was intended to be a flexible system by means of which a manned satellite could be built up to any desired size. In comparison with Vanguard's 20in sphere, even Mr. Romick's "very small" ferry rockets would seem to need more than the fifteen years allowed for their development, testing and launching. His example of a "very large" satellite measuring 3000ft by 1000ft diameter and complete with church and supermarket, was received with some amusement by the delegates. However, it is not likely that Vanguard represents the last word in astronautics; already space travel shows signs of becoming a sizeable industry. In this connection it was of interest to note that some of the constructional details shown in the METEOR report bore a distinct resemblance to those previously used in the dirigibles once built by Goodyear. Other evidence of the interest of American firms in advanced astronautical projects was provided by a Rand Corporation report on the requirements for establishing unmanned artificial satellites of the moon, read by R. W. Bucheim. He established that an optically observable satellite of the moon could be set up in a retrograde orbit by use of a rocket vehicle with a mass of about 1,000,000 lb if the guidance were performed within errors of one-twentieth of those expected for the Vanguard vehicle.

A note of caution was sounded by Major D. G. Simons, of the Space Biology Branch of the U.S. Air Force, who gave some preliminary results obtained on the effect of heavy primary cosmic radiation on mice, monkeys and other animals, which had made balloon flights of up to thirty hours duration at altitudes of above 30,000km. Seeds and eggs were also exposed. While the health hazards for manned flight in satellites or high-altitude rockets are still unknown, various effects were observed, including injury of nerve cells and greying of black mice because of damage to hair pigment cells. The streaks of grey hairs suggested radial spread of radiation effects twenty times predicted values. J. Gerathewohl, of the U.S.A.F. School of Aviation Medicine, presented the results of a series of experiments on weightlessness. A Lockheed T-33 aircraft was flown in dives and parabola flights to give practical weightlessness for periods of from ten to thirty seconds, and subjects were asked to record their personal experiences. Perhaps not surprisingly, the sixteen subjects could be divided into three groups, according to whether their experiences were pleasant, unpleasant, or indifferent (Mr. Gerathewohl belonged to this group). The majority of the subjects found the weightless condition pleasant, one of them going so far as to state "Actually, I've never been so comfortable in all my life; and I think that if I had my choice of places to relax, a weightless condition would be definitely it. I must add, though, that at no time did it have a drugging effect on me." A film taken during the experiments was screened, and showed that during the weightless periods mercury shaken about in a bottle would behave as if it were water. On squeezing water out of a plastic bottle it floated gently around the cabin until the aircraft pulled out of the parabola. Experiments on weightlessness have also been made at the Centro di Studi e Ricerche di Medicina Aeronautica in Rome by Professor T. Lomonaco, M. Strollo, and L. Fabris. They used a cockpit suspended by elastic cords inside a tower 14m high; initially the cockpit is fixed to the base of the tower, then the cords are stretched and the cockpit released. The subjects can be exposed to accelerations ranging from 3 g (fractions of a second) to zero g (total time four seconds), and the effect on their motor co-ordination determined by testing their ability to hit with a pencil the four quadrants of a circle at a natural rhythm, trying to distribute the points equally. Under these experimental conditions a slight loss of motor co-ordination was observed and unpleasant sensations were reported by the subjects, but on exposure to several consecutive runs they became accustomed to the conditions.

One of the five technical sessions was concerned mainly with propulsion. H. J. Käppeler and G. Baumann dealt with the calculation of equilibrium constants for chemical reactions by use of statistical mechanics. B. Langenecker presented a paper and film to illustrate the effect of unstable combustion in rocket motors on the properties of metals. Failure of the motors is attributed to a frequency-dependent reduction in yield point and elasticity, together with cavitation. E. A. De Zubay, of the Curtiss-Wright Corporation, New Jersey, considered the turbo-jet and rocket combustion chambers as systems of successive homogeneous chemical reactors of infinitesimal volume in continuous sequence. At present the data required for the use of this method are limited almost exclusively to the air-propane system. H. Bednarczyk, of Austria, analysed the thermodynamic processes of the steam rocket, and W. Peschka, also of Austria, considered the possibility of increasing the exhaust velocities of rockets. The use of solar power in space flight was investigated by Krafft A. Ehricke, Chief of Preliminary Design and Systems Analysis, Convair-Astronautics Division of General Dynamics Corporation, U.S.A.

The only British contribution came from T. Nonweiler, of the College of Aeronautics, and concerned skin heating during re-entry of satellite vehicles into the atmosphere. Only the spiral stage of entry was considered and it was shown that the highest temperature reached at the leading edge of the wing (produced when the vehicle is travelling at a speed of $\sqrt{2/3}$ times the escape velocity, i.e. at 6·5km/sec) need be no more than 1000 deg. Cent. The measures adopted to reduce the temperature include the use of a wedge wing with a small loading constructed from material of high conductivity and good emissivity.

Among the other subjects discussed were space law, lunar rockets, the design of step rockets, photon rockets, photoelectric intensity measurements in the extreme ultra-violet, and the use of nuclear energy.

Dr. Leslie R. Shepherd, of the Atomic Energy Research Establishment, Harwell, and vice-chairman of the British Interplanetary Society, was elected president of the I.A.F. The retiring president, Mr. F. C. Durant, was elected a vice-president, as were Professor Sedov (U.S.S.R.), T. Tabanera (Argentina), P. J. Bergeron (France), and J. Marial (Spain). The first award of the Günther Löser Memorial Medal was made to Krafft A. Ehricke, for his paper presented at the Sixth Congress. The next Congress is to be held in Barcelona in October, 1957.

Central Electricity Authority

THE eighth annual report of the Central Electricity Authority, which was published last week, relates to the year ended March 31, 1956. In that period the C.E.A. power stations generated over 75,500 million units of electricity, an increase of 9·4 per cent over the previous year ; in the same period the number of consumers increased by 443,000, or 3·2 per cent ; and the average price per unit increased by 2·3 per cent to 1·403d. per unit. The operations of the Authority and the twelve Area Boards, taken together, produced a surplus of revenue over expenditure of £12,212,242, which together with previous surpluses makes a total of £70,740,000 in the eight years since vesting day.

Capital expenditure during the year was £137,070,000 by the Authority and £76,260,000 by the Area Boards. New generating plant was commissioned in thirty-seven power stations and provided an increase of 1632MW in the output capacity of the C.E.A. system. Seven new tations came into operation during the year : Fleetwood, Goldington (Bedford), Marchwood near Southampton), Meaford "B" (Stone, Staffs), Portishead "B" (near Bristol), Stella North (near Newcastle upon Tyne), and Wakefield "B." Marchwood is primarily oil burning, but is also designed to burn pulverised coal. A record was achieved by reducing the amount of generating plant out of service for overhaul during the critical winter months of December and January to 1·6 per cent of the available total in 1955–56, compared with 2·7 per cent in 1954–55 and 4·1 per cent in 1948–49.

Two new sections of the 275kV super-grid system were completed and brought into operation during the year under review : they consist of 47 miles of double-circuit line between Staythorpe (Newark) and Drakelow (Burton-on-Trent) and 109 miles between Staythorpe and Elstree. Two other sections were made operational initially at 132kV : one circuit of 46 miles between Elstree and Tilbury and the other of 19 miles between Drakelow and Hams Hall, near Birmingham. By the end of the year under review the total length of 275kV lines working at 275kV or 132kV or under construction was 1500 route-miles.

There was still, however, a shortage of plant. At the time of maximum potential demand, which occurred on February 2, 1956, it became necessary to reduce load by over 1700MW to prevent overloading of generating plant and transmission equipment. Despite the fact that the rate of installation of new generating plant in recent years has been higher than previously recorded, the total amount of post-war plant installed in England and Wales by the end of 1955 was below that originally planned ; 771MW (sent out) of new plant programmed for the years 1950–55 had still to be brought into commission. This, however, was an improvement of 225MW on the position at the end of 1954, when 996MW from the 1950–54 programmes were outstanding.

Nuclear Generation and Fuel Supplies

The Authority's programme of twelve nuclear power stations in ten years was outlined in the 1954–55 Report. Construction of the first two stations is planned to start in 1957, and it was an urgent task to find suitable sites. A nation-wide survey for possible sites was neither necessary nor practicable in the time available. The requirements clearly pointed to the south of England, where there are heavy demands for electricity and little local coal, and to estuaries or the coast for large volumes of cooling water. Wide areas were surveyed, and it soon became apparent that the best facilities were offered by the Essex coast, stretching northwards from the Thames estuary, and the south-eastern bank of the Severn estuary, although within these areas suitable supplies of cooling water were quite localised. By October, 1955, it was possible to announce that sites near Berkeley, Gloucestershire, and Bradwell-on-Sea, Essex, had been chosen by the Authority. The local planning authorities gave their approval in principle to the use of these sites, and in July, 1956, after a public inquiry, the Minister gave his consent to the establishment of the station at Bradwell, and subsequently, in the same month, he gave his consent for the station at Berkeley. In each case the consent was for a station containing turbo-generator sets having an aggregate electrical output of about 200MW and two carbon dioxide gas cooled, graphite moderated reactors.

Competitive designs of the first two stations are being prepared by each of four industrial groups (of turbo-alternator and boiler manufacturers, associated with civil engineering contractors) formed to undertake this kind of work. An inquiry specification covering the broad requirements was prepared by the Authority in consultation with the Atomic Energy Authority, and tenders for construction of the stations will have been submitted by each group by October 1, 1956. This invitation to tender for a complete station is a departure from normal procedure. The design of the station as a whole depends on the reactor characteristics and output, and it is therefore advantageous that in each case it should be undertaken by one project team. In contrast to coal-fired power stations, the greater portion of the cost of electricity from present practicable designs of nuclear stations will arise from capital charges. The capital cost per kilowatt sent out is largely influenced by the output that can be obtained from each reactor, which is at present limited by engineering considerations, and for this reason the output capacities of the two stations were not specified, although a lower limit of 150MW was fixed in each case.

Oil Fuel.—Reference was made in the 1954–55 report to the agreements with two oil companies for supplies of heavy fuel oil to power stations which are to burn oil, some being converted for the purpose. The arrangements now apply to seventeen stations, and it is estimated that the total consumption of oil will rise to about 5¾ million tons per year, equivalent to some 9,000,000 tons of coal. The stations are as follows :—Bankside "B" (London), Barking "C," Belvedere (near Erith), Bromborough, Brunswick Wharf (Poplar), Cliff Quay (Ipswich), Ince (near Ellesmere Port), Littlebrook "B" (Dartford), Littlebrook "C," Marchwood (near Southampton), Northfleet, Plymouth "B," Poole, Portishead "B" (near Bristol), South Denes (Yarmouth), Tilbury, and West Thurrock. Bankside "B" has been in commission since the end of 1952 and Marchwood since the end of 1955, as oil-fired stations. Carrington (near Manchester), which was included in the earlier list given in the 1954–55 report is to remain coal-burning.

With the introduction of oil firing on an appreciable scale, and the development of nuclear generation, probable changes in the pattern of fuel supplies may be envisaged. Home-produced coals of the low grades used for electricity generation will tend to be absorbed at decreasing distances from their sources, and oil will be used mainly at power stations near the coast and within reach of refineries or deep-water berths for tankers ; but the cost of fuel for nuclear stations is virtually independent of location. Fuel transport costs, however, are only one element in the siting of new power stations, and rigid zoning of the three classes of station would be uneconomical and impracticable.

Power Station Planning and Design

Underground Gasification.—The Authority has been represented for some years on the Scientific Advisory Panel of the Ministry of Fuel and Power dealing with the underground gasification of coal. The panel has been supervising experimental work at two sites in the Midlands, and during the year the Authority made an economic appraisal of the possibility of power generation from gas so produced. Although the experiments have been on a very limited scale and for relatively short periods, it was established that a power station as small as 10MW would be uneconomic. A case might possibly be made out later for a larger station, say, of 60MW, provided it was near to centres of load and transmission distances were short.*

Hydro-Electric and Pumped Storage Schemes.—During the year the Authority obtained powers, under the North Wales Hydro-Electric Power Act, 1955, to undertake two further water power projects : a pumped storage scheme of 300MW generating capacity near Blaenau Ffestiniog, and a conventional hydro-electric scheme of 49MW capacity based on the River Rheidol. The pumped storage scheme will be the first of its kind in Great Britain. It will provide an economic means of supplying peak load generating capacity, using low cost energy derived from thermal generating plant at times of low system demand. The Rheidol scheme has also been designed for peak load operation.

Steam Supplies and District Heating.—An agreement was signed with a large industrial firm at Spondon, near Derby, for the supply of process steam up to a maximum demand of 600,000 lb per hour. The supply will be provided by back-pressure generating plant to be installed at Spondon Power Station. Preliminary design work on the proposed group steam supply scheme at Warrington was completed, and commercial negotiations were in progress regarding the terms of supply. There were further investigations into two schemes for the supply of steam to large industrial consumers ; in each case the supply is required for a new factory which it is proposed to build close to an existing power station.

In the fourth year of operation of the Pimlico district heating scheme, ended September, 1955, the number of flats connected rose to 2270 and the heat sent out from Battersea Power Station was 660 therms per flat, as compared with 650, 680 and 630 in the three preceding years. A second test of heat losses was conducted on an experimental length of distribution main during the winter period.

Plant Design and Development

The plant programme for 1961, which was approved by the Authority during the year, includes five units of 200MW, six of 120MW, one of 100MW, and four of 60MW. With three exceptions, these installations are for stations started under earlier programmes. In addition, the 1961 programme includes up to 400MW of nuclear plant and 199MW of pumped storage and conventional hydro-electric plant.

Reference was made in the 1954–55 Report to the major design features of the first 200MW generating sets to be adopted by the Authority. The development of these units and of ancillary plant, for the new power station at High Marnham, near Tuxford, continued during the year, and work was started on the outline design of two further 200MW unit stations, one proposed at West Thurrock, on the Thames estuary, and the other at Willington, near Derby. The latter will adjoin the Willington "A" station which is, under construction, and both of these stations will be of semi-outdoor design, on the lines of Ince, near Ellesmere Port.

The first units for High Marnham have been developed primarily for base load generation ; but investigation of the problems associated with two-shift operation—such as the relative expansion of turbine fixed and moving parts, thermal stressing, and the control of steam temperature from the boilers at low flows—has led to the conclusion that units of this class can be made suitable for daily starting-up and shutting-down. This is a novel conception for units of such a size, none of which has yet been built in Britain ; and prior experience of base load working will be necessary so that the operational characteristics of the machines can be explored.

The decision to introduce nuclear power plant on a large scale, and the probability that it will be advantageous to use it for supplying base load, make it necessary that new non-nuclear plant should be designed for flexibility of operation. It has therefore been made a general requirement that all such plant should be fully suitable for two-shift operation, and current specifications define the transient conditions to be met during starting up, and the rates of loading

* Since the end of the year it has been decided that the National Coal Board and the Authority should be jointly responsible for further research and development, with the assistance of the Gas Council and Gas Boards.

required. The latest turbine designs for the 200MW unit show considerable development over the first ones, and to a large extent meet the requirement of flexibility. Particular attention has also been given to improvements in the maintenance of continuous output when needed, and on the latest machines facilities are being provided which will enable the correct functioning of the turbine protective equipment to be checked without the unit being taken off load.

In the case of the boilers for the 200MW units the major requirement for flexibility of operation is the ability to produce an adequate steam temperature at low flows to meet the turbine requirements, and investigations have been made to this end. It is also necessary to consider some form of variable speed drive for the boiler feed pumps, so as to minimise wear and tear on the feed water regulating valves under the onerous conditions which occur at starting up. Although more than one design is possible, operational experience at such large powers is limited, and arrangements are being made for a full-size prototype hydraulic coupling to be installed in an existing station. The problem of water circulation in the boilers has also received attention, and there is a general indication that natural circulation is practicable with the rated steam outlet pressure of 2450 lb per square inch gauge.

There have also been developments in the case of the 120MW reheat units, and it is now judged that these units can be made sufficiently flexible to accept two-shift loading. The plant programmes have therefore been reviewed to substitute this larger plant wherever practicable, so as to secure its advantages in lower capital and operating costs. Twenty-six units of 60MW each, which were planned for installation in five power stations, are being replaced by thirteen of 120MW. Some delay may be occasioned by the changeover, but the introduction of other programmed plant is being accelerated wherever practicable. Few further 60MW sets will be installed by the Authority, except to complete certain stations already under construction.

The generator for the first High Marnham unit will employ internal cooling by hydrogen for both stator and rotor conductors ; but designs have also been developed for liquid-cooled stators for generators of the 200MW rating, and arrangements have been made for smaller units already under contract to employ this form of cooling in order to obtain advance experience. The trend towards higher hydrogen pressure continues. Most 120MW units are being designed for a pressure of 30 lb per square inch gauge with some form of direct cooling of rotor conductors.

Tests of specimens cut from a welded pipe joint of chromium-molybdenum-vanadium steel indicate that satisfactory welds of adequate creep strength can be made under site conditions with pipes of this material, and it has been decided to use this steel for the high-pressure steam pipework at the High Marnham station. It is expected that ferritic steels, although not necessarily this particular type, will be used for the pipework in all the 200MW units.

Some of the largest generating units will be connected to the 275kV transmission system, and high response voltage regulators, utilising magnetic amplifiers, will be employed to provide the rapid regulation of voltage which stability considerations make desirable. This is not regarded as essential in the case of the 132kV system; but as it is expected that maintenance costs will be reduced as compared with the older type of regulator, a number of high-response regulators have been installed to enable operating experience to be gained. Cold-reduced grain oriented steel is being increasingly used in the smaller sizes of generator transformers.

In connection with the development of the new thermodynamic cycle referred to in the 1954–55 Report, work proceeded on the design and construction of a superheater test rig at Littlebrook Power Station, Dartford. The equipment consists essentially of a superheater element, fired by pulverised coal, in which steam at 200 lb per square inch is heated from 965 deg. Fah. to a final temperature of 1400 deg. Fah. The combustion air is preheated regeneratively, and enters the burner at a temperature of about 1600 deg. Fah. The performance of the superheater element is being studied prior to the design of a complete assembly for testing the cycle.

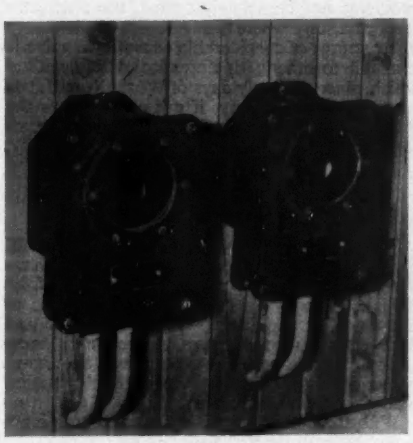
Further developments in centralised control technique in power stations included remote control of the turbine starting valves from the unit control centre, and progress was made towards integrating control of the generating units with that of the station as a whole.

The increase in size of power stations poses new problems in the economical handling of coal at high rates. At High Marnham, stocking and reclaiming will be by reversible conveyors of special design working in conjunction with wing trippers and ground hoppers ; whilst pressure breakers of a new design will be provided in the bunkers to reduce the flow troubles that arise when handling wet coal. Much work has been done on the handling and disposal of ash, and one novel device under experimental trial is a combination of revolving cutter and water jets for unloading damp ash from barges.

Fuel Efficiency Exhibition

THE Fuel Efficiency Exhibition this year is being held, for the first time, in London. On Tuesday last, at Olympia, it was opened by Mr. Aubrey Jones, M.P., Minister of Fuel and Power, and it will continue until October 10th. During the exhibition a series of technical meetings, organised by the Institute of Fuel, are being held in the Conference Hall. On Wednesday this week the subject was "The Efficient Use of Coal," and the speakers were F. B. Karthauser and R. Nichol ; yesterday, G. Richardson and A. B. Pritchard, A. E. Tyrrell, and J. I. Bernard dealt with the same subject in relation to oil, gas, and electricity respectively.

On Tuesday next, from 10.30 to 12.30, Air Chief Marshal Sir Leslie Hollinghurst will be in the chair at a meeting to hear L. Clegg on "Heat and Power Surveys" and G. N. Critchley on "Waste Heat Recovery." On Wednesday, October 10th, Sir Hugh Beaver will preside over a discussion on "The Clean Air Bill and Industry," which will be summed up by Dr. G. E. Foxwell.



A pair of photoelectric daylight monitors

From the exhibition the impression gained is that a very high efficiency in the use of fuel can be obtained by any user prepared to make the appropriate capital investment in equipment. Many of the exhibits will be familiar to engineers, featuring as they do steam-raising plant and auxiliaries. There is a marked emphasis on the use of automatic controls for undiverted vigilance and high precision in the supervision of combustion and other processes. There are also displays, such as those of John Thompson, Ltd., and Babcock and Wilcox, Ltd., showing instruments and fabrications for use in nuclear power stations.

One of the more specialised exhibits is a logical extension of the principle of off-peak electrical heating, using the structural concrete of the building as the heat accumulator. Shown by Thermodare (Great Britain), Ltd., 94–98, Petty France, S.W.1, the storage heater consists of a galvanised mild steel element which is enclosed loosely in a sheath of polyvinyl chloride ; it is claimed that this is tough enough to stand the impact of builders' barrows and harsh treatment while the floor is being laid. An edged tool can penetrate the sheath, but in that event the length of element affected could be replaced without disturbing the floor, since the element runs backward and forward between access ducts. These ducts also accommodate, in a separate channel, the electric supply cables. The ducts, when laid, are filled with sand, so that they form part of the heat store. The covers of the ducts are of open trough section to accept the same finish as the rest of the floor. The system is controlled by time switches to limit the hours of charge to those in which "off-peak" tariffs prevail, and by thermostats with a time constant of the order of one day to sense the severity of the weather.

Another device that conserves electricity in the simplest possible way—turning it off—is the daylight monitor, shown by G.E.C. This is used to switch on lights when the daylight is no longer adequate for the activity in progress and to extinguish them again when not needed. A photoelectric cell and a single valve amplifier operate the device, which can control circuits up to 900VA without the intervention of an external contactor. The sensitivity of the device can be varied by a control, which may be remotely mounted, between 0·4 lumens per square foot and 8 lumens per square foot ; extensions to this range involve changing the mask of the window. The circuit is such that failure of the unit or its supply turns on the light ; chattering of the contacts when the illumination is near the critical level is also eliminated. The unit itself consumes about 0·1A on 240V a.c.

Hitherto the efficiency of furnaces has often been limited by the phenomenon of corrosion in parts of the gas passages that ran at or near the acid dewpoint. A process for the control of low-temperature corrosion, developed in the laboratories of the British Petroleum Company, Ltd., at Sunbury, promises to end this restriction at a reasonably low cost. Since measures to raise the temperature of the flue gases invariably compromised the efficiency, and since to reduce the sulphur content of the fuel is not commercially practicable, a wide range of chemicals were tested with a view to neutralising sulphur trioxide by absorption or combination : most success was obtained with those that combined directly. Solid additives needed to be used in concentrations far above theoretical because of inefficient dispersion, while a gas would not suffer this handicap. It was found that ammonia reacted readily with the flue gases ; at low ammonia concentration, ammonium bisulphate was formed, which can itself be corrosive below 150 deg. Cent. A higher concentration neutralised the sulphur trioxide completely with the formation of ammonium sulphate, with the result that corrosion became negligible and deposits were easily washed away.

The temperature at which the ammonia is injected is important ; too high a temperature (above 590 deg. Cent.) causes decomposition of the ammonia. The optimum range is 300 deg. to 400 deg. Cent., i.e. in boilers, either between superheater and economiser or between economiser and air heater. Full-scale trials have been carried out on a boiler intended for a gas temperature of 140 deg. Cent. after the economiser, which had actually been run at 170 deg. Cent. to obtain an economiser tube life of three years. The acid dewpoint was 135 deg. Cent. when burning oil containing 3·3 per cent sulphur, and to neutralise this 0·08 per cent by weight of ammonia was added. The injection system consisted of a rectangular loop of ¾in mild steel tube drilled with a number of holes. Corrosive condensation on the tubes was prevented, and by allowing a lower feed water inlet temperature fuel consumption was reduced about 3 per cent. An injection system would require an automatic

flow control relating the proportions of ammonia and fuel according to combustion conditions : it is anticipated that the cost of ammonia would be less than 1s. 6d. per ton of fuel.

On the Shell-Mex and B.P. stand lectures on the process are illustrated by means of an apparatus in which the products of combustion of a facsimile high-sulphur fuel are divided into two streams and passed through glass chambers containing water-cooled mild steel test specimens. The gas entering one chamber is dosed at 350 deg. Cent. with ammonia ; the tube in this stream gains a dry, whitish film of ammonium sulphate, while the other becomes covered with sulphuric acid and corrosion products. At the exit from the chambers condensation detectors consisting of platinum electrodes in a glass tube are mounted ; the resistance between the electrodes remains high in the treated gases, but falls as a conducting film of sulphuric acid grows on the other. Both these detectors run at 70 deg. Cent.

Opposite this lecture theatre on the first floor, the United Kingdom Atomic Energy Authority has another elaborate display. A particularly attractive item is a model reactor in which the primary coolant circuit is represented by discharge tubes, inside which the heat exchanger elements can be seen. Models are also displayed of advanced reactors expected to be in use at the end of the present ten-year programme.

Symposium on the Plastic Theory of Structures

A SYMPOSIUM at which the present stage of progress in the development of the plastic theory of structures was discussed, was held at Cambridge from September 18th to 21st. The papers discussed at the symposium were printed in the August issue of the *British Welding Journal* and were grouped under the following heads : single-storey frames ; multi-storey frames ; foundations ; thermal stresses ; impact ; frame instability ; design problems ; and teaching of plastic theory. These headings cover most of the work now going on, and one of the aims of the symposium was to draw attention to some of the less-known amongst them. We reproduce below an abstract from Professor J. F. Baker's introduction to the symposium.

The idea of designing a structure against collapse is by no means new. The builders of mediæval cathedrals certainly used the principle in evolving their structures. Euler's discussion of struts and all the varied design methods for compression members which have grown out of it are based on considerations of collapse. In modern times the principle has been commonly used in aircraft design. Plastic design is, of course, the collapse method applied to mild steel structures.

Strangely enough, despite the inherited engineering tradition of design against collapse and of the vast experience gained over more than fifty years with mild steel structures, plastic design is new. The reason is not far to seek. Precisely because the steel-framed structure became of such importance it seemed necessary to codify the design process so that buildings could be quickly designed and erected. This codification, which took place at the beginning of this century in the early days of the steel structure, had the awful effect of stultifying further scientific inquiry into the problems of steelwork design. So long as the designer knew that his building would be safe if designed according to the Code and so long as he knew it would take effort to persuade local authorities to accept a design which did not satisfy the Code, he was not likely to have the wish to inquire more deeply. Thus, structural engineering became bedevilled with the concept of permissible stresses and a blind faith in elastic theory until the engineer's structural sense has become almost atrophied.

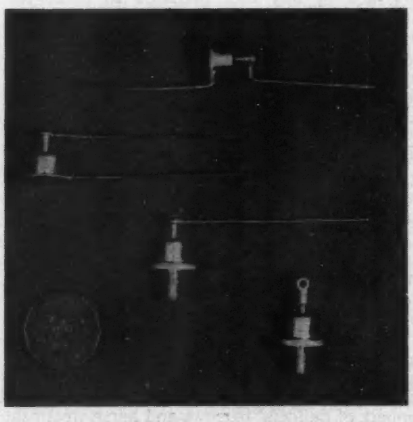
The competition from reinforced concrete once, nearly thirty years ago, aroused the spirit of inquiry and brought into being the Steel Structures Research Committee, which attempted to throw some light on the dark magical practices of rule of thumb. The investigations of the behaviour of actual multi-storey steel-framed buildings showed how completely confused and irrational was the orthodox code method of design. The Committee after six years' effort succeeded in producing a rational method of design, though it applied only to regular forms of multi-storey structures. The Committee's work —tests on full-scale structures and attempts to evolve a sound method of design acceptable to engineers—produced something of much greater importance, namely evidence that the behaviour in the elastic range of a practical structure with its many redundancies was far too complex, far too much influenced by the inevitable practical " imperfections," variations of joint behaviour, sinking of supports, locked-up stresses, and so on, ever to yield a simple rational design method acceptable to the designer. It was inevitable, therefore, if there was ever to be further development in the use of steel in structures by the introduction of welding or otherwise, that attention should be turned to plastic behaviour and " collapse " methods of design. This is still not fully realised by structural engineers. The only real choice is between plastic methods of design, which allow of new developments, and the traditional quasi-elastic methods which are so irrational as to allow virtually no scope for development.

It was against this background that the Cambridge team has worked since 1943, continuing what was started at Bristol in 1936. Attention has not been confined to the problem of major scientific interest ; an attempt has been made to push the boundaries of knowledge forward in an unbroken line so that the engineer has information available which will enable him to design structures. While there are many problems not completely solved, the work has reached a stage where a new branch of the theory of structures of considerable educational value is available together with a practical design method which, since the early days of World War II, has been applied effectively, if not as widely as the economic position of the United Kingdom seems to warrant.

Silicon Junction Rectifiers

WE illustrate some examples of a series of low-power silicon junction rectifiers which have been developed in the research laboratory of the British Thomson-Houston Company, Ltd., at Rugby. For applications where small size and high working temperatures are required, these silicon junction rectifiers offer advantages compared with the range of germanium junction made by the same company.

With these silicon rectifiers, a maximum junction temperature of 200 deg. Cent. is possible, allowing operation in ambient temperatures up to 175 deg. Cent. At such high temperatures, inverse voltages up to 300V are possible. Alternatively, if the maximum junction temperature is limited to 120 deg. Cent., allowing operation in ambient temperatures up to 100 deg. Cent., a higher inverse voltage is possible and units are being made up to 400V. The accompanying tables list the various experimental types of silicon rectifier that have been produced, giving forward current ratings over a range of ambient temperatures.



Alternative arrangements of B.T.H. silicon junction rectifiers : we show two wire ended units, a stud-mounted unit with top flying lead and a stud-mounted unit with top soldering tag

Another important application of the silicon rectifier is as a voltage reference (Zener diode), particularly in the range of 4V to 8V. Such units have also been developed and are suitable for junction temperatures up to 250 deg. Cent. The table gives further information on these diodes.

High-Temperature Silicon Junction Rectifiers

Development Type No.	Maximum I.V.	Maximum mean output current: 25 deg. Cent. ambient	100 deg. Cent. ambient	150 deg. Cent. ambient	Maximum junction temperature
SJDX10A ...	50	0·75A	0·5A	0·3A	200 deg. Cent.
SJDX11A ...	100				
SJDX12A ...	200				
SJDX13A ...	300				

Medium-Temperature Silicon Junction Rectifiers

Development Type No.	Maximum I.V.	Maximum mean output current: 25 deg. Cent. ambient	75 deg. Cent. ambient	100 deg. Cent. ambient	Maximum junction temperature
SJDX12B ...	200	0·5A	0·3A	0·15A	120 deg. Cent.
SJDX13B ...	300				
SJDX14B ...	400				

Voltage Reference Silicon Junction Rectifiers

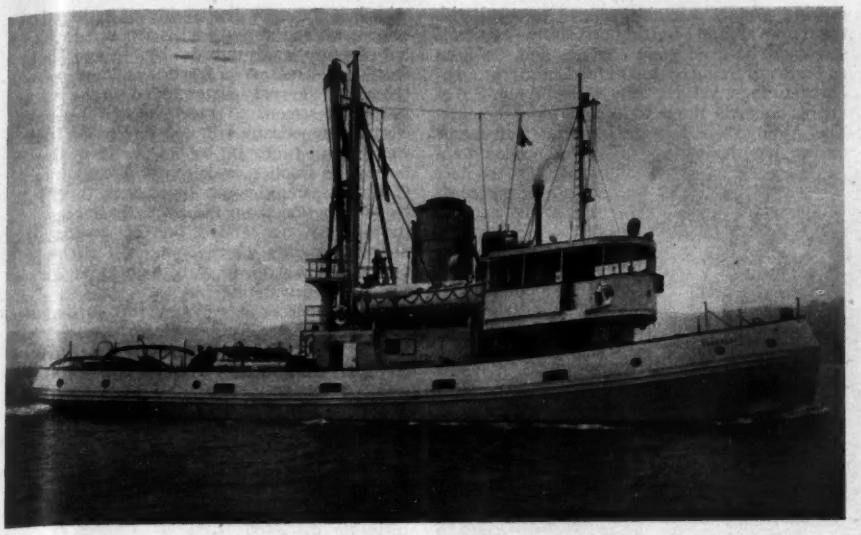
Development Type No.	Reference voltage	Maximum current at reference voltage: 25 deg. Cent. ambient	100 deg. Cent. ambient	150 deg. Cent. ambient	Maximum junction temperature
SJD9A/4 ...	4	0·3A	0·2A	0·14A	250 deg. Cent.
SJDX9A/6 ...	6	0·22A	0·15A	0·1A	
SJDX9A/8 ...	8	0·15A	0·1A	0·07A	

All these units are enclosed in similar capsules, hermetically sealed by means of a projection weld. They are being made in three forms, as illustrated—wire ended, stud-mounted with top flying lead, and stud-mounted with top soldering tag. The silicon rectifiers are available in experimental quantities for use in development work and in prototype production.

Twin Screw Tug "Takoradi"

THE Crown Agents for Oversea Governments and Administrations recently accepted the twin screw steel tug " Takoradi " upon the successful completion of trials, and the ship will leave shortly to take over duty at Takoradi. The tug, which was built by Philip and Son, Ltd., under the supervision of Rendel, Palmer and Tritton, has a length between perpendiculars of 105ft, a breadth moulded of 28ft 9in, and a depth moulded of 14ft, and has been constructed to Lloyd's special survey " For Towing Services on the Gold Coast." During the trials, which were carried out in Start Bay, the tug attained a free running speed of 10·6 knots. A static bollard pull of 16·2 tons was also recorded.

A cabin is provided for the master on the open bridge, and another for the engineer in the deck-house, which also houses the galley and provides access to the crew's accommodation, forward on the main deck, consisting of two cabins and a mess room. There is also crew's accommodation, including a mess room, below deck aft. Special provision is made for the handling of buoys, the after deck being kept clear for this purpose, the equipment including a 10-ton derrick operated by a Clarke Chapman



Twin screw tug "Takoradi"

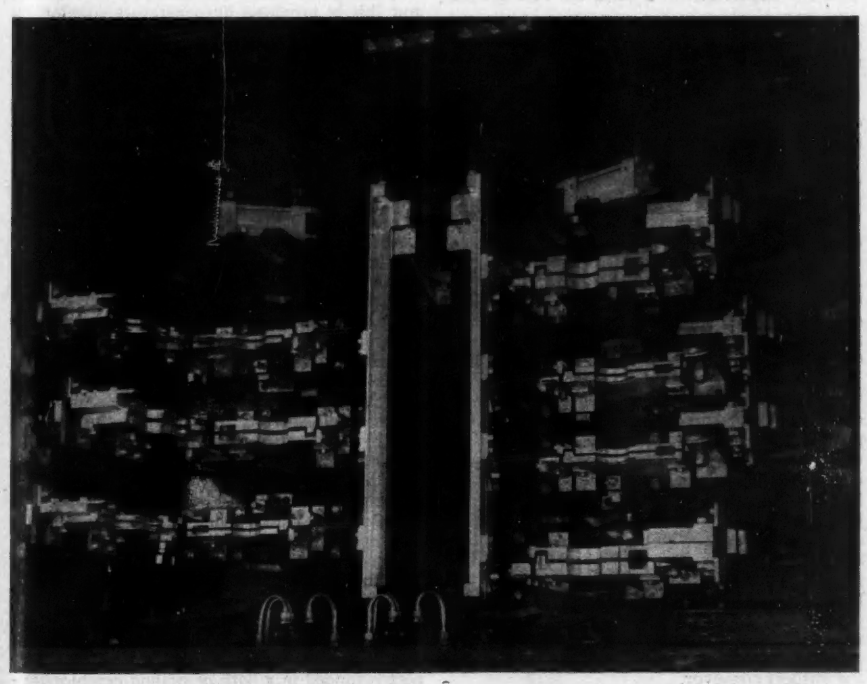
steam winch. The same manufacturer has also supplied two steam-driven capstans for handling buoy chains over a bow roller; the port unit is suitable for 1¼in cable and the starboard unit for 1⅛in cable, and both can exert a pull of 3 tons at 40ft per minute on the port side and 6 tons at 20ft per minute on the starboard side at the same time. Two "Monarch" towing hooks, each of 17 tons safe working load, are fitted at the aft end of the engine casing and the two 19ft aluminium alloy lifeboats are carried under Columbus "Col-Crescent" davits. "Hyland" hand and electric hydraulic steering gear controls the twin rudders. Two swivelling monitors mounted on towers abaft the funnel are supplied by a steam-driven Merryweather "Greenwich Gem" fire pump which is capable of delivering 1550 gallons of water per minute at 140 lb per square inch.

Plenty and Son, Ltd., built the main machinery, which consists of two sets of handed triple expansion engines, each developing 400 i.h.p. at 120 r.p.m. and driving a four-bladed manganese bronze propeller of 8ft diameter by 10ft mean pitch which works in a Kort nozzle. Steam is supplied at 200 lb per square inch by a single-ended oil-fired Scotch marine return tube boiler, operating under Howdens forced draught, and Drysdale and Co., Ltd., Thom, Lamont and Co., Ltd., and G. and J. Weir, Ltd., have supplied the pumps, while Richard Crittall (Marine), Ltd., has provided the mechanical ventilation system for the engine and boiler-room and the accommodation. Electrical requirements are met by a 15kW steam-driven generator and a 5kW diesel-driven generator. Wing tanks and a cross bunker carry 89 tons of boiler fuel and 5 tons of feed water are carried in a double-bottom tank between the engines.

Crankshaft Hardening Plant

An induction-heating crankshaft hardening plant, which is claimed to be highly economic for throughputs of a few hundred shafts a week, is being marketed by Radio Heaters, Ltd., Eastheath Avenue, Wokingham, Berks. For each pattern of crankshaft a jig plate is assembled with inductors for each bearing. Two or three throws can be hardened at one station, so for a four-cylinder crankshaft the bearings will be processed on each side of the plate; our illustration shows a set-up for hardening the centre main and outer big ends on the left, and the outer mains and inner big ends on the right. An automatic switching mechanism transfers the power from a bearing on one shaft to a bearing on the other, and floods the first with water. This sequence continues until all the bearings have been treated, when the two shafts are interchanged by the operator. Manual control allows one bearing to be treated at a time. An automatic rematching unit enables the r.f. generator, which gives 50kW at 450 kc/s, to be fully loaded throughout the cycle.

The plant, which will accept shafts up to 42in long, weighs 3 tons. Water at 60 lb per square inch is required. Two gallons per minute being consumed to cool the r.f. coils and 10 gallons per minute for quenching.



Jig plate, showing two sets of inductors for one pattern of crankshaft

Diesel-Electric Locomotives for Eire

Some notes have been received from Sulzer Bros. (London), Ltd., on the twelve main line diesel-electric locomotives being supplied to Coras Iompair Eireann. These new locomotives will supplement the two Sulzer locomotives which have been at work on the Dublin-Cork route since 1950-51, and which themselves are now being rebuilt to an output of 960 b.h.p. from the 915 b.h.p. of the originals.

The power equipments of the new locomotives are of the first Sulzer design railway oil engines to be built by Vickers-Armstrongs, Ltd. When the order was placed in 1948 as part of C.I.E.'s programme at that time, it was for six 1800 b.h.p. express locomotives. Shortly afterwards that programme was altered, but the power equipments were, by then, almost completed. After considerable discussion C.I.E. decided to order twelve locomotives to a new general-purpose design from the Birmingham Railway Carriage and Wagon Company, Ltd., in which the equipments could be embodied, and which would have a maximum axle load of 15 tons. Meanwhile developments in the Sulzer pressure-charger and in certain details of the engine had been made, and it was found possible to incorporate some of these in the engines before actual installation in the locomotives. Thus, the output of the 6LDA28 engine which, in 1948, was 915 b.h.p. at 750 r.p.m. as a one-hour figure, and 815 b.h.p. at 700 r.p.m. on the continuous basis, is now 960 b.h.p. at 710 r.p.m. as a continuous rating.

The locomotives have an A1A-A1A wheel arrangement with a weight in working order of 75 tons and a maximum axle load of 14¾ tons. The adhesion weight is about 57 tons and maximum starting tractive effort 41,800 lb. The rail tractive effort on the continuous rating of the electrical equipment is 16,900 lb at about 16 m.p.h., and the top designed speed is 75 m.p.h. The principal dimensions are: wheel diameter, 37½in; bogie wheelbase, 10ft 6in; bogie pivot pitch, 24ft 10in; total wheelbase, 35ft 4in; length over frame, 45ft.

A six-wheel modified Pennsylvania design swing-bolster bogie used is generally similar to those fitted to the Sulzer-Birmingham locomotives of the Commonwealth Railways of Australia. Each bogie frame is an integral welded steel structure in regard to the main longitudinal and cross member, but has separate axle-box guide plates secured by driven bolts. A welded bolster, which carries a flat pivot and side bearers, is not separately sprung, the swing links are supported on knife-edges and side swing is controlled by hydraulic stabilisers. The suspension is arranged in the form of nests of helical springs between each compensating beam and the bogie frame, and is supplemented by hydraulic shock absorbers.

There is a driving cab at each end. A double swing door midway down each side panel gives ready access to the engine-room, in which there is a clear, wide walkway all the way round the engine-generator group. Water and oil cooling radiators on the side panels immediately behind No. 2 driving cab are connected by trunking to the motor-driven fan in the roof.

The engine and the Metropolitan-Vickers main generator and auxiliary generator are carried on a common welded steel subframe forming part of the engine crankcase structure.

Medium-Voltage Withdrawable Switchgear

THE photographs reproduced here show part of a new range of medium-voltage, withdrawable electric switchgear, which is being produced by George Ellison, Ltd., of Perry Barr, Birmingham.

The new switchgear, which will be known as the "GEO" range, comprises horizontally isolated draw-out circuit breakers for service voltages of up to 660V and with carrying capacities of 400A, 600A, 800A and 1200A. The circuit breakers have been A.S.T.A. tested in accordance with B.S. 116 : 1952 at 600V. The breaking capacities are :

Fig. 1—Medium-voltage switchboard with horizontally isolated withdrawable circuit breakers

Current rating	Breaking capacity at 600V	Breaking capacity at 400V	Minimum coil size to give stated MVA	A.S.T.A. Certificate No.
400A	37·5MVA	25MVA	200A	3438
600A	45MVA	30MVA	400A	3443
800A	45MVA	30MVA	600A	3451
1200A	45MVA	30MVA	600A	3480

As illustrated in Fig. 2 the main and arcing contacts are individually reversible ; a complete moving contact assembly can be reversed with the removal and refixing of only two set-screws. The fixed main contacts and the fixed and moving arcing contacts are identical throughout the range, varying only with the number of arcing contacts fitted to each size of breaker. This arrangement has the important advantage of keeping the variety of spares needed to a minimum. The contact mechanism is protected by a spring-assisted, oil-filled shock absorber. When the oil tank is full, a single operation of the breaker is normally sufficient to ensure that the shock absorber is full. The spring protects the contact mechanism when maintenance needs call for operation with the tank lowered.

Series-wound, solenoid-operated overcurrent and undervoltage releases give protection to consumer's plant. The overcurrent releases are adjustable between 90 and 200 per cent full-load current. They are fitted with triple-action dashpot time lags that allow transient high overcurrents to pass, but operate release on sustained overcurrents, dependent upon their setting. The undervoltage coil acts directly on the trip mechanism. A shunt trip coil may be fitted in place of the undervoltage coil or one of the overcurrent coils.

Withdrawal of a circuit breaker to isolate it from the busbar chamber is simple and safe ; the circuit breaker cannot be closed until full isolation is completed, and the cover and tank are interlocked so that removal is only possible after isolation.

Auxiliary switches may be fitted as compact units in moulded cases. They are easily fitted to the circuit breaker within the oil tank, below the level of the oil. A circuit breaker may have two units, each providing for two normally open or two normally closed single-pole switches.

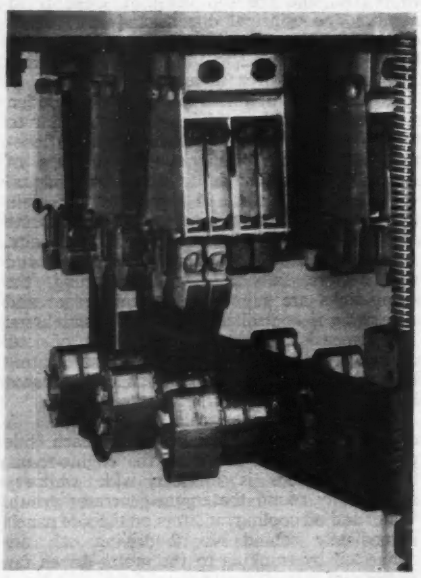


Fig. 2—Moving contacts on the "GEO" circuit breaker can be reversed after removing two set-screws

Coal Preparation Plant in Australia

THE Fraser and Chalmers Engineering Works of The General Electric Company, Ltd., has recently installed at the Corrimal Colliery in New South Wales the first coal preparation plant with Chance equipment. This plant has a capacity of 200 tons an hour of 6in raw coal and is situated about a mile away from the mine drift.

The raw coal is brought up the drift in skips of approximately 30 cwt capacity, by means of a steam haulage engine. After uncoupling from the haulage rope, the skips gravitate to a rotary tippler, from which the raw coal is discharged into a surge bin. This bin is provided with a feeder, fitted with a bar grizzly at the discharge to pass a 6in product. The oversize material is discharged into a single-roll crusher for reduction to minus 6in, after which it joins the natural 6in by 0 fraction on a belt conveyor delivering into a 100-ton capacity bunker.

A haulage way used for lowering the raw coal down the incline from the colliery to the coal preparation plant has two 15 tons capacity skips, one at each end of the haulage rope. The drive is automatic, and once the starting push button has been pressed, the skips are accelerated to their normal travelling speed, and then decelerated and brought to rest, without any further action on the part of the operator. On reaching the bottom of the incline, the skips run over the top of a 200-ton bunker, where their power-operated bottom discharge doors are opened for the contents to be discharged. A scraper-feeder on the bunker regulates the rate of feed on to the washery conveyor.

The coal is delivered to the plant by a 30in wide belt conveyor discharging on to the primary screen, where the raw coal is separated with the aid of spray water into 6in by $\frac{1}{2}$in and $\frac{1}{2}$in by 0 fractions. The smaller fraction is laundered with the aid of the spray water added on the primary raw coal screen, to two Sherwen high-speed electro-magnetically vibrated screens for further wet screening into $\frac{1}{2}$in by $\frac{1}{4}$in by $\frac{1}{4}$in by 0. The 6in by $\frac{1}{2}$in fraction is delivered directly into the Chance washing cone, together with the $\frac{1}{2}$in by $\frac{1}{4}$in fraction from the Sherwen screens. All the spray water added on the primary and Sherwen screens which contains the $\frac{1}{4}$in by 0 fraction flows on to two high-speed zimmer screens for dewatering.

The Chance cone, which is 10ft in diameter, has been designed for a single gravity separation with products of clean coal and refuse. Provision has been made for the cone to be converted to make a two-gravity separation for producing clean coal, middlings and refuse if required in future. The connection on the cone for the middlings column has been blanked off for the time being, but the middlings column can be fitted in a very short time without structural alterations.

Refuse extracted from the Chance cone is desanded and dewatered on a shaker screen and delivered to a 20-ton capacity bunker for disposal. The clean coal is also desanded and dewatered on a shaker screen which grades the coal into 6in by 3in, 3in by 1in, and 1in by $\frac{1}{4}$in sizes. The two largest of these sizes are loaded into rail wagons by chutes, and the smallest size is delivered by a conveyor and into wagons.

The $\frac{1}{4}$in by 0 fraction of the raw coal feed is laundered, together with all the spray water added on the primary and Sherwen screens, to the two zimmer screens. The coal is dewatered and separated by these screens at a nominal size of $\frac{1}{2}$mm, the $\frac{1}{4}$in by $\frac{1}{2}$mm fraction being delivered by conveyor to the 1in by $\frac{1}{4}$in washed coal. The water used for laundering contains the $\frac{1}{2}$mm by 0 fraction and is passed to a 45ft diameter thickener for concentration. The clean water from this thickener overflows into a clarified water sump for re-use in the washery circuit. The solids, which settle to the bottom of the tank, are extracted by a diaphragm pump and delivered to a bottom-feed drum filter. This filter reduces the moisture content of the $\frac{1}{2}$mm by 0 coal to approximately 25 per cent, and the filter cake is then discharged on to a conveyor for delivery to the $\frac{1}{4}$in by $\frac{1}{2}$mm dewatered and the 1in by $\frac{1}{4}$in washed coal.

The design of the plant is very simple, and at the present time only three operators are actually employed, including the foreman. Under full load the power absorbed amounts to 195kVA, and this is provided by generators running on waste heat from the Corrimal coke ovens.

Metal Finishing Processes

ON the occasion of a recent visit to the new factory at Hemel Hempstead of Roto-Finish, Ltd., we were given a demonstration on a pilot plant of one of the processes of Farbwerke Hoechst, Frankfurt in Main, that the firm has introduced to this country. This was the "Atram" O-S. process, a method of phosphating at room temperature, during which sludge is not formed. A metal sheet was degreased in a non-foaming "Grisiron" alkaline spray, washed in water, sprayed in the phosphating agent, rinsed, sprayed with an after treatment, and water washed once more. The phosphate coat is of very fine grain, allowing a high gloss to be obtained on painting : test pieces were displayed to show that paint adhered better to metal treated in this way than to untreated steel thoroughly cleaned. It is claimed that the corrosion resistance of "Atram" O-S. phosphating is at least equal to that of hot processes, and that flexibility and adherence are superior. Light rusting is removed in the process, the spraying stages of which take from one to five minutes each, while the coating will withstand temperatures up to 220 deg. Cent., allowing bituminous paints to be applied.

Another process demonstrated was the "Pertrinol" method of metal cleaning. The part is dipped in a bath of boiling perchlorethylene, within which small solid particles remove

insoluble deposits by attrition. The "Pertrinol" is extracted from the cleansing agent before it is distilled and re-used. It was shown that the mechanical action of this plant gave a cleaner end product than the normal perchlorethylene degreasing. A method of drying plated parts without leaving stains that must subsequently be rubbed off was also shown: this "A.S.L." metal drying process removes the water from the surface in a bath, instead of evaporating it and leaving the mineral content on the plated surface.

From the barrelling techniques of polishing, edge radiusing, and de-burring, Roto-Finish has now evolved a process of treating long slender objects. These are loaded into the "Roto-Ram" machine and reciprocated in a stationary mass of chips flooded with water. By selecting the material of the chips and adding agents to the water, or by varying the speed of the stroke, the effect can be controlled, and machining marks may be removed in one-half to one-quarter the time taken by hand and power tool methods. The illustration shows

High-tensile steel spar booms before and after surface finishing in a "Roto-Ram"

high tensile steel spar booms before and after polishing in a "Roto-Ram" at Hawker Aircraft Ltd. A machine is now in course of construction for Westland Aircraft, Ltd., to give a high surface finish to light alloy helicopter blade spars over 30ft long.

Fatigue tests on light alloy specimens, performed by Vickers-Armstrongs (Aircraft), Ltd., have shown that surface finishing by the "Roto-Ram" is as effective as hand finishing with power tools, so that this much less expensive process can justifiably be applied to critical components.

Track Lifting and Scarifying Equipment

THE illustration at the top of the page shows a new track lifting and scarifying unit which is being used by the North Eastern Region of British Railways to scarify the formation and break up old sleeper beds immediately in advance of track renewal or ballasting, without removing the track. This equipment, which has been under development, is 8ft long and 10ft 6in wide, and consists of a flat steel plate base with two rows of scarifying tines welded to the underside in chevron formation. A detachable plough can be fitted on the plate behind the tines. On the upper side of the plate are three arched ribs, one central and one under each rail, which are designed to support and bring the weight of the track over the tines during the ploughing operation. The weight of the assembly is approximately 1½ tons.

The device is towed by a locomotive by means of a harness consisting of four wire ropes and a spreader bar as shown in the illustration. By adjustment on the shackles fitted to the wire ropes it is possible to offset the equipment up to 12in

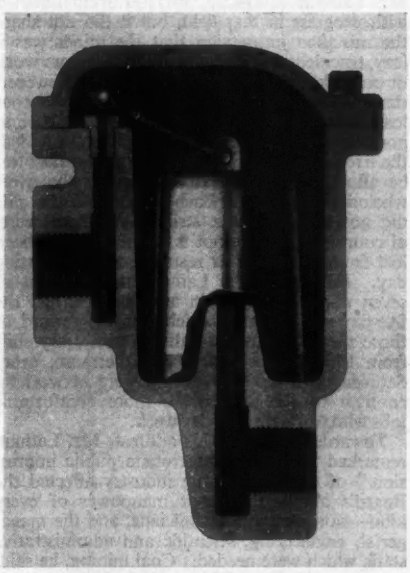
Scarifying equipment in position under the track and being towed by a locomotive. Tines on the underside of the plate base scarify the ballast which is redistributed by a detachable plough at the rear of the tines

(sleeper ends permitting) over a short distance. As the equipment moves along the track, boxing ballast is redistributed by the plough, leaving the track about 2in above its original level. If desired, the detachable plough can be fitted to divert some scarified ballast from the centre of the sleepers to beneath the rails, to reduce risk of subsequent centre binding. It is also possible to provide still greater additional depth of ballast beneath the track by distributing new ballast on to the track ahead of the plough.

It has been found that the normal penetration of the scarifying tines into old sleeper beds is about 5½in, and that the general disturbance of old ballast containing a proportion of dirt effects some measure of top ballast cleaning.

Inverted Bucket Steam Trap

THE range of steam traps manufactured by Lancaster and Tonge, Ltd., Pendleton, Manchester, has recently been augmented with the introduction of a new design of inverted bucket steam trap. This unit steam trap has a double leverage action, which enables large diameter seatings to be employed, and gives a large capacity-to-size ratio. It is made in cast iron for the two steam pressure ranges of 0 lb to 100 lb and 100 lb to 200 lb per square inch gauge



Cut-away view of unit steam trap

saturated, and the internal fittings are stainless steel with the exception of the float, which is made of copper, although it is hoped to make this of stainless steel in the future. At present ¾in and 1in size traps, which weigh 7 lb, are being manufactured, but it is understood that a ½in trap weighing 4 lb will be available shortly.

The cut-away view of the trap which we reproduce shows that it consists of a small cylindrical box containing an inverted float, on the top of which is a slotted bracket. A pin working in the slotted hole connects the float to an operating lever having as fulcrum a pin in a slotted hole in the lever bracket located by the valve seating. A ball valve is carried at the top of the lever and a funnel connects the trap inlet to the open bottom of the float. The float remains resting on the bottom of the box and holding the ball valve open when water and air enter; the entry of steam, however, displaces the water and causes the float to rise and so close the valve, which continues to remain closed until more condensate enters and forces the steam to escape through a small vent hole in the top of the float. With the escape of the steam the float loses buoyancy and sinks and so opens the ball valve against the pressure inside the trap to discharge the condensate. The maximum discharge of ¾in and 1in traps when passing condensate continuously at 10 deg. Fah. below steam temperature is given as rising from 500 lb per hour at 10 lb per square inch gauge to 925 lb at 100 lb per square inch gauge, the quantities for the pressure range, 100 lb to 200 lb per square inch gauge, being 450 lb to 550 lb. The corresponding figures for the ½in trap are stated to be 250 lb to 465 lb and 230 lb to 280 lb of condensate per hour.

Aluminium Sheathing

To provide economical protection for insulation materials an aluminium covering has been developed by Corrosheath, Ltd., 29, Bury Street, St. James's, London, S.W.1, in conjunction with Venesta, Ltd. This form of protection, known as Corrosheath aluminium jacketing, is designed for enclosing steam, hot water, chemical and oil pipes. The jacketing is manufactured from 0·006in thick aluminium foil, which is corrugated to provide additional strength. In general, the jacketing has an asphaltic moisture barrier, consisting of Kraft Union waterproof paper, glued on to prevent corrosion where the insulation material is alkaline, but is also supplied plain. The material is available in rolls 24in wide by 100ft in length and can be cut to size on the site and secured in place with aluminium strapping which is 0·02in thick by ¾in wide and available in 5 lb coils. In way of bends the insulation can be covered by a 3in wide soft tempered aluminium strip applied like a bandage.

Industrial and Labour Notes

Industrial Production

According to statistics published in *Bulletin for Industry*, which is issued by the Treasury, this country is not producing more this year in total, but it is producing more both for industrial investment and for exports. Consumer demand as a whole has flattened, and there have been fewer home market sales of cars. Defence expenditure on goods and services has also fallen. The *Bulletin* says that these have been among the main factors which have resulted in a levelling of total industrial output. Over the first seven months of this year, the "all items" index of industrial production was a little higher than in the corresponding period of last year.

The *Bulletin* shows, however, that in the manufacturing industries output in the first half of this year was nearly 1 per cent lower than in the comparable period of last year. Employment in manufacturing has also declined, but not so rapidly as output, which implies some fall in output per man. The two main groups in the production index which cover the metal-using industries—vehicles and engineering, shipbuilding and electrical—include both consumer and investment goods. In total, both groups have fallen this year, the rise in capital goods being insufficient to offset the fall in consumer durables and defence. The production of capital goods as a whole increased by 3½ per cent between January and May. In the vehicles group, there were big rises, in the first half of the year, in aircraft, and smaller increases in the production of locomotives and rolling stock, and commercial vehicles. The fall in the production of passenger cars, tractors, motor-cycles and cycles, the *Bulletin* says, was the biggest factor in the decline of the vehicles production index in the first six months of the year.

Wages and Productivity

On Thursday of last week, Sir Graham Hayman, president of the Federation of British Industries, spoke at a meeting, in Bradford, of F.B.I. members in the East and West Ridings. During his address, Sir Graham referred to the much-discussed subject of wages and productivity, saying that no policy of price restraint on the part of employers could be successful unless there was also co-operation from the side of labour.

To talk of a wage freeze, Sir Graham commented, was misleading, for the incentive of higher wages—where they could be afforded—was more than ever desirable to encourage mobility and to provide incentives for skill and efficiency. Using the fruits of greater productivity to keep prices steady, Sir Graham added, was at the present time the fairest and most effective way of distributing the benefits of an increase in the national income. Moreover, there could be no more serious setback to the renewed export drive which was now under way than for wages to continue to rise without a corresponding increase in productivity. If the impetus of the export drive was lost, Sir Graham said, our present prosperity and all that had been achieved since the war would be most seriously threatened.

Restraint, Sir Graham continued, was only another name for responsibility, and the present, he claimed, was a time when the exercise of responsibility by all sides of industry was urgently needed. He therefore appealed to employers and trade unions alike to show the greatest sense of responsibility during the coming months.

Average Earnings and Hours

The Ministry of Labour has now published particulars resulting from its latest investigation of average weekly earnings and working hours in the United Kingdom. The inquiry related to the last pay week in April and was concerned with manual wage earners employed in manufacturing industries and in a number of the principal non-manufacturing industries. Among the employments excluded from the inquiry, however, were coal mining, agriculture, railways, shipping, port transport, and British Road services.

In the industries examined, the Ministry received information from about 69,000 establishments, the total number of wage earners covered being just over 7,000,000. The average earnings in the last pay-week of April in all the industries included in the inquiry were : men, £11 15s. 4d.; youths and boys, £5 0s. 6d.; women, £5 19s. 9d., and girls, £3 18s. 4d. In the manufacturing industries only, the average earnings were : men, £12 2s. 2d.; youths and boys, £4 17s. 6d.; women, £6, and girls, £3 18s. 8d. If the figures for the manufacturing industries are examined in more detail, it is shown that the average earnings in the engineering, shipbuilding and electrical goods group were : men, £12 12s.; youths and boys, £4 17s. 2d.; women, £6 10s. 8d., and girls, £4 1s. 8d. It will be recalled that the Ministry of Labour conducts an inquiry into average weekly earnings twice a year. From this latest survey it has deduced that, when all the industries included are considered together, the increases in average weekly earnings since April, 1947, are : men, 91 per cent ; women, 78 per cent, and youths and girls, 110 per cent.

In all the industries surveyed, the average hours worked in the last pay week of April were : men, 48·6 ; youths and boys, 45 ; women, 41·5, and girls, 42·4. The corresponding figures for the last pay week of April, 1947, were : men, 46·3 hours ; youths and boys, 43·7 hours ; women, 41·5 hours, and girls, 42 hours.

Coal Mining Disputes and Absenteeism

In an address to the Coal Industry Society, in London, last Monday, the chairman of the National Coal Board, Mr. James Bowman, said that coal mining disputes were still one of the greatest difficulties in the industry. Up to September 15th, there had been 2880 separate stoppages of work this year, which had cost 1,450,000 tons of coal. There was a great need, Mr. Bowman urged, for the acceptance and use of the agreed conciliation machinery. Stoppages of work should be the last and not the first resort, and that was a view which was shared by the unions.

The same theme was elaborated by the deputy chairman of the Coal Board, Mr. J. Latham, when he spoke to the members of the Manchester Coal Exchange last week. He said that one of the Board's great problems was to maintain its labour force, and he also mentioned the hope that had been expressed that nationalisation would bring much more effective co-operation within the coal mining industry. The Board, Mr. Latham continued, was far from satisfied with progress in that field, but it did not share the mistaken impression that the miner was a lazy, truculent fellow, frequently away from work or on strike. It would be idle to deny, however, that there were places where the record of output lost through strikes, restrictions of effort, and non-attendance was indefensible. But, he added, the irresponsible action of the minority must not be allowed to obscure the record of the overwhelming majority. Each year, half the pits did not have a single strike and there were, of course, pits where not a ton of coal had been lost from stoppages or restrictions since vesting day. Moreover, Mr. Latham said, six out of seven miners at work in any week earned the five-day week bonus, which was the reward of those men who attended the pits on every shift from Monday to Friday. Furthermore, every Saturday over 200,000 miners were at work in contrast to the millions in more comfortable jobs who worked a five-day week.

Towards the end of his address, Mr. Latham remarked that "the unfortunate public impression" of the coal mining industry affected the Board's ability to recruit manpower of every kind—workmen and technicians, and the managerial, engineering, scientific and administrative staffs which were needed. Coal mining, he said, must have its share of recruits from the schools and universities, but as contrasted with the bright prospects held out by newer industries, such as chemicals and atomic energy, it was often presented as a dying and unsuccessful industry with no career prospects for promising young men. But, on the contrary, Mr. Latham emphasised, the opportunities for young men of energy and resource, of courage and drive, in the coal industry were immense.

Industrial Efficiency

In the course of his chairman's address at the annual meeting of The General Electric Company, Ltd., on September 27th, Sir Harry Railing deplored the fact that, like every new technique capable of wide use, automation had become a subject of controversy. Automation, he said, was the normal and natural result of technical development, and it should be obvious that Britain could not afford to fall behind in the application of automation techniques. Automation, Sir Harry asserted, was essential to maintain a reasonable living standard. Its obvious advantages, however, must not make us insensitive to the human problems always connected with such developments ; they would have to be resolved in joint consultation.

Sir Harry went on to say that with the relative inelasticity in the growth of manpower in the United Kingdom, and with the added burden of having to support an increasingly ageing population, the accelerated application of automation in Britain had come just in time. The output of our industries could not be significantly increased if we relied on the availability of more pairs of hands to man more machines. Under those conditions, Sir Harry observed, to discourage automation would be suicidal. In 1948, the labour force in manufacturing industry totalled 8,137,000, with the index of industrial production at 100, and the average weekly hours worked 44·9. In 1955, with a labour force of 9,337,000 in manufacturing industry, working 46·4 hours a week, the industrial production index rose to 142, of which 22·5 per cent was attributable to productivity.

This meant, Sir Harry continued, that if the state of efficiency in industry had remained static since 1948, without further introduction of labour-saving machines, manufacturing industry would have had to employ not 9,337,000 people as it did to-day, but 11,171,000 to produce the nation's current output as indicated by the production index. In fact, by enhanced efficiency the country had added the labours of some 1,834,000 productive people and enjoyed the benefits of that increased output. The industrial revolution, Sir Harry suggested, was not something we had once experienced and left behind ; we were constantly living through it.

Work Study in Ordnance Factories

The British Productivity Council has prepared a review, entitled "Ammunition Production." It deals with such matters as work study methods in the Royal Ordnance Factories, and stresses that the process research now going on in the ordnance factories, and the interest in work study, ensure that, should the need for sudden expansion ever again arise, Britain would be in a far better position to meet it than she was in 1939.

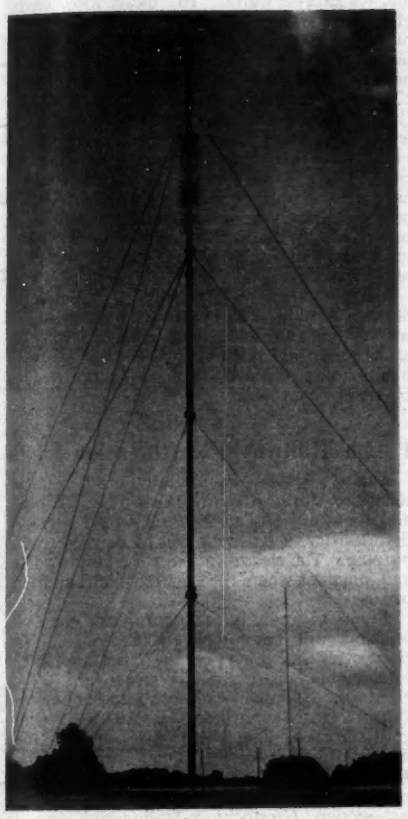
The review points out that the manufacture of armaments absorbs a vast industrial effort which clearly it would be preferable to employ for almost any other purpose. That it should occupy the bare minimum of industrial capacity is evident, the review says, for "waste of resources in an activity itself inherently wasteful would be doubly deplorable." It is added that great progress in the production of ammunition has been made during the past few years by using labour and machines to the best advantage. Some idea of the results of increasing productivity, the review records, are gained from the fact that prices of many kinds of ammunition have not risen in ratio with wages and cost of materials ; in fact, prices of some kinds have even been falling during the past five years.

Radio and Television Mast at Steinkimmen

A FEW weeks ago the radio and television mast at Steinkimmen, between Bremen and Oldenburg, was completed. This steel mast is 298m high and is the second highest structure in Europe after the Eiffel Tower, and the highest structure in the German Federal Republic.

It is to radiate the German television programme and the two sound programmes of the Nordwestdeutscher Rundfunk, all of which go out on metre wavelengths. Because of the quasi-optic properties of propagation of such waves the mast had to be built to the great height mentioned, in order to cover adequately the required area.

As may be seen from our first illustration,



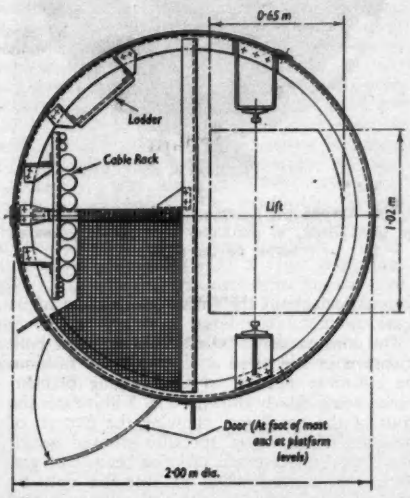
Radio and television mast, Steinkimmen. Tubular steel construction with lattice top, total height 298m

the mast is circular in section, the section being constant along the whole length. This is the most economical design and gives a small wind resistance, at the same time the radio-frequency and service cables and the service lift can be installed in a manner which protects them from the weather.

Accordingly, the mast was built as a steel tube of 2m diameter with wall thicknesses ranging from 6mm to 10mm.

Another requirement which had to be met was that the aerials had to be readily accessible. With the television aerials, the reflectors for which are 4·50m wide, there was sufficient space between the reflectors and the mast to allow an inspection platform to be fitted. On the other hand, the f.m. dipoles for sound broadcasting are only 1·66m wide. For the dipoles, therefore, a thinner top section had to be used which was carried out in open lattice construction. In order to achieve minimum wind resistance the lattice top was constructed from round bars. This portion of the tower is 31m high and is cantilevered, the first set of guy ropes being attached just below it, to the top of the tubular section.

The design for wind resistance was based on air velocities of 129km per hour near the



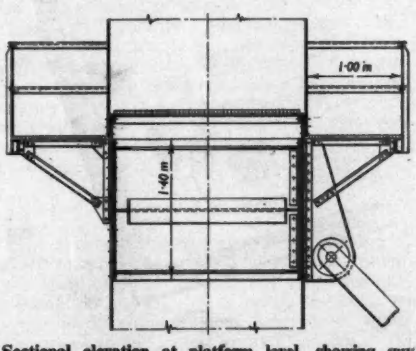
Section through mast, showing bolted tubular construction with three plates to each 3m high section

ground, and 184km per hour near the top of the mast (this compares with Beaufort 12=145km per hour). These values lead to wind loads on the cylindrical part of about 80 kg per metre near the ground, and about 155 kg per metre at the level of the topmost guy ropes. Not including the wind force on the guy ropes themselves, the total maximum design wind load on the structure is approximately 62 tons. The largest deflection at the top is about 2m.

In the design of such a mast, the question of buckling had to be considered, as well as the problem of vibrations. A difficulty was introduced by the fact that the guy ropes are deformed under the working tension sufficiently to alter significantly the geometry of the structure. Calculation had therefore to proceed by a process of iteration, as in the case of suspension bridges.

The cylindrical part of the mast is built up from curved sheets 3m long and one-third of the total circumference in width. These plates are bolted together into rings and provided with stiffeners at the joints between successive cylindrical sections. For the attachment of the guy ropes, welded connections are used, as shown below. Inside the mast are fitted the lift for two persons (which occupies half the cross section and is separated from the other half by a grille), a ladder, and the cable racks for radio-frequency, telephone and power lines.

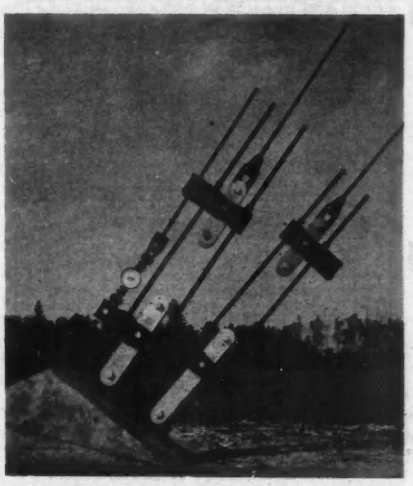
The top part of the mast is prefabricated in 4·8m long sections, which are bolted together by means of flats welded to the corner rods.



Sectional elevation at platform level, showing guy rope attachment and stiffening rings

Externally, the mast carries eight platforms, one at each guy rope attachment and one at each of the four television aerials. The platforms are accessible through doors from the inside of the mast, the top platform being reached from the ground by lift in approximately nine minutes. No platforms are provided for the f.m. dipole, as it can be reached from within the lattice mast.

The Steinkimmen radio and television mast is erected on sandy soil with a high water table, necessitating the use of piled foundations. The guy ropes are taken in pairs to six anchorages which are also of piled construction. Each foundation consists of three to six piles, ranging in diameter from 32cm to 40cm, and 10m long, some being designed for compression and some for tension. The weight of the mast, including



At each anchorage two guy ropes are attached. Here the ropes are being adjusted by means of dynamometers which are afterwards replaced by stays

guy ropes and antennæ, but excluding the foundations, is 240 tons. The load on the supporting ball bearing is 387 tons, the guy rope tensions contributing, from top to bottom, 67, 54, 13 and 13 tons, respectively.

The guy ropes consist of a number of parallel cast steel wires, each 4mm in diameter. Because of the absence of twist, such ropes do not stretch and act like elastic rods in tension. For the same reason, they cannot be wound on reels, and so have to be specially made on the site.

For the assembly of the mast, for which approximately 70,000 bolts were required, the usual procedure was followed of building up the mast plate by plate, using a crane mounted within the completed portion. Working in single shifts, an average assembly speed of about 5·6m per day was achieved for the mast itself. If delays due to the addition of platforms and fixing of guy ropes are included, the average speed of erection was 3·5m per day. After completion of the erection work, the mast had to be set vertically and the rope tensions adjusted. For this purpose use was made of dynamometers fitted near the anchorages and afterwards replaced by metal straps as illustrated above. The design and construction were carried out by Hein, Lehmann and Co., A.G., of Düsseldorf.

Improved Car Headlamp

In the double-filament car headlamp the long-distance beam is produced by a horse-shoe-shaped filament at the focus of the parabolic reflector, while the dipped beam is produced by a straight second filament arranged along the reflector axis in front of the main filament. This second filament is provided with a small screen, which is fitted underneath it. The screen serves to remove that portion of the light which would be reflected in such a way as to reach the road at a greater distance ahead of the car than is desirable if dazzling of the oncoming driver is to be avoided. In Fig. 1(*a*) is shown the light distribution from such a headlight. The illumination is symmetrical about the vertical plane, and

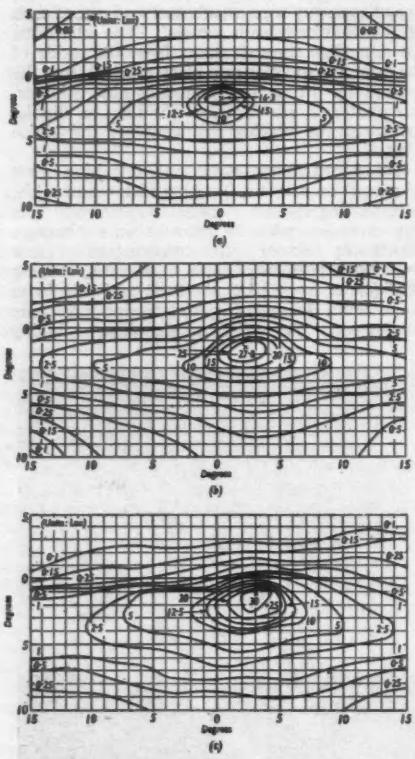


Fig. 1—Comparison of light flux from three designs of headlamp. (a) symmetric headlamp, 180mm diameter; (b) "sealed-beam" headlamp; (c) asymmetric headlamp, 180mm diameter

it may be noted that the flux falls away rapidly from its maximum of 16·3 lux at 1½ deg. below the horizon to 0·5 lux at 0·3 deg. above the horizon, giving a rather sharp change from light to dark on the road surface in front of the car. A distribution such as the one illustrated gives only weak illumination of the nearside (which is on the right in most European countries). Fig. 1(*b*) shows the American "Sealed Beam" searchlight in which an asymmetrical distribution is obtained by partially cutting away the filament screen and using a suitably patterned front glass cover. More recently Robert Bosch G.m.b.H., Stuttgart, in co-operation with Philips Gloeilampenfabrieken, Eindhoven, and others, have developed a headlamp working on similar principles. Its light distribution is shown in Fig. 1(*c*).

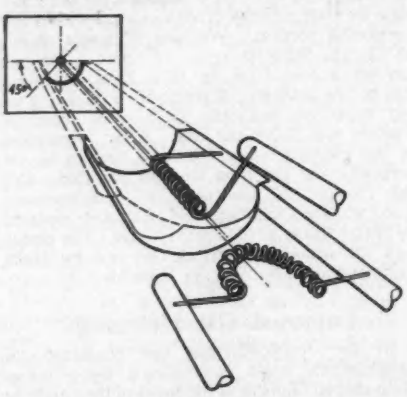


Fig. 2—Diagrammatic view of asymmetric bulb, showing the partially cut-away screen underneath the secondary filament

It will be seen that compared with the symmetrically dipped headlamp, the new design sends its maximum light flux in a direction of 3 deg. right of centre, i.e. towards the Continental nearside. By contrast with the "sealed beam" light, the falling-off of intensity in the upward vertical direction is more rapid to the left and in the centre of the beam than on the right, whereas the "sealed beam" light is more nearly

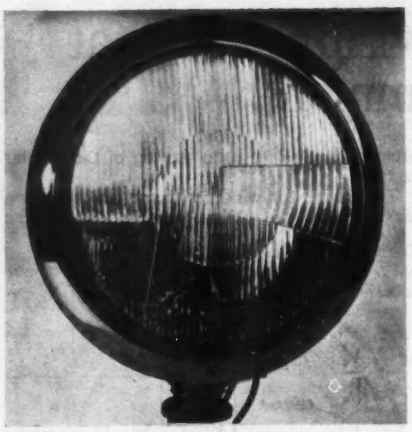


Fig. 3—Asymmetric headlamp, showing the pattern of the glass front, in particular the specially grooved sector on the right

symmetrical about the (offset) centre line of its beam.

The construction of the Bosch headlight bulb is shown in Fig. 2 in a diagrammatic fashion, the cut-away portion of the dipping filament screen being clearly shown. Fig. 3 illustrates the front of the headlamp, showing the pattern of the glass which has a specially grooved sector where the long-distance kerbside beam emerges. Since the desired effect is obtained only by employing the correct combination of bulb and glass lens, the bulb for the new design has its cap permanently attached to a special socket, so that an interchange with ordinary bulbs is rendered impossible.

Remote-Reading Inclinometer

Our illustration shows an instrument for the indication of changes in the inclination of structures, which has been developed by H. Maihak A.G., Semperstrasse 26/38, Hamburg, 39. The installation consists of the indicator and any required number of sensitive elements (not illustrated) which may be placed on the structure at any desired distance. The elements are built in a number of designs, suitable for fixing to vertical or horizontal surfaces, for insertion in pipes or shafts, and for inclusion in concrete during the casting. Each element may be connected in turn to the measuring unit by means of a selector switch. The principle of operation is the comparison of liquid resistances in the element which vary with the inclination. Lack of balance of the resistances is indicated on a galvanometer, and balance is restored by rotating the main dial of the instrument, which has 100 divisions to either side of zero. Elements with sensitivities up to three seconds of arc per division are available. The U.K. agent is Smail, Sons and Co., Ltd., 62, Robertson Street, Glasgow, C.2.

Indicator of remote-reading inclinometer showing selector switch, galvanometer and balancing dial

German Railway Developments

The progress of the German Federal Railways* is illustrated by the fact that in the period January to May, 1952, German locomotives covered 286 million kilometres, while in the corresponding period this year the figure was 309 million kilometres. Further modernisation of the rolling stock is in hand. Of an order worth DM.500 million for railcars and engines, some are already being delivered. The order comprises 250 electric locomotives of four designs; 24 electric railcars taking current from overhead lines or a third rail; 50 battery railcars; 300 diesel locomotives of 650 h.p. for shunting or suburban service; 50 diesel locomotives of 2200 h.p. for express trains; 105 diesel locomotives of 107 h.p. for light shunting; 15 multiple-diesel railcars of 1000 h.p. and 2000 h.p., and 250 diesel motor coaches of 150 h.p. and 300 h.p. At present, the German Federal Railways have 1777 diesel vehicles in service.

As for electrification, a total of 2136km of lines have already been electrified, and a further 1180km, it is stated, will be electrified before the end of 1957, so that when the current schemes have been completed, a total of 3300km, or 10·8 per cent of the German network, will have been converted to electric traction. This figure represents a 100 per cent increase since the end of the war.

Among other novel designs, the German railways have recently introduced a goods wagon with sliding roof and movable walls. This can carry goods which, by reason of their shape or bulk, had up to now to be carried in open wagon covered by a tarpaulin.

Polish Railway Electrification Plans

Almost 9000km of railway lines will be electrified during the Five-Year Plan, 1956–60, and about one-fifth of the total capital outlay of the Ministry of Railways will be devoted to this purpose. The electrification will embrace routes and junctions where the greatest suburban traffic occurs.

Suburban traffic in Stalinogrod and the Lodz junction will be completely electrified. The electric railway routes on the coast and in the surrounding districts of Warsaw are to be extended. The main railway route Stalinogrod-Cracow will be electrified as well as the Stalinogrod-Wroclaw line, with two branch lines through Pyskowice to Opole and through Tychy and Bielsko to Zywiec. Between Warsaw and Stalinogrod work will be completed on the last section, Czestochowa-Stalinogrod, electrification scheme.

In addition, the line from Warsaw to Kutno is to be electrified as a beginning to the planned link-up with Poznan. In the Cracow region, electric trains are to run to Nowa Huta and to Podleze.

The implementation of such an important programme will enable the Polish railways to transport 20 per cent of their goods traffic by electric trains, and so save about 1,000,000 tons of coal annually.

French Railway Electrification

It is announced that the inauguration of electric traction on the line Bellegarde-Geneva took place on September 27th. In consequence, trains between Paris and Geneva, and between Lyon and Geneva, are being electrically hauled throughout since September 30th, when the winter time-tables came into use. The new electrification is at 1500V, d.c. The next stages in the South-East of France will be the electrifications between Dijon and Vallorbe, scheduled for completion by the end of 1957, and between Lyon and Nîmes via Avignon, which, it is stated, will be ready by 1961.

*C.I.C.E. *Bulletin*, September, 1956

Work of the U.S. Atomic Energy Commission

BY OUR AMERICAN EDITOR

No. II—(*Continued from page 457, September 28th*)

ALTHOUGH considerable progress was made on certain phases of the Sodium Reactor Experiment (SRE) during the present reporting period, some other phases were delayed. As a result the fabrication of the reactor by Atomics International, a division of North American Aviation, Incorporated, at Santa Susana, California, now is expected to be completed this autumn (Fig. 3). This reactor, of 20MW heat capacity, will use liquid sodium as coolant and graphite as moderator, since sodium makes possible high temperatures without a high-pressure reactor vessel. Thus high thermal efficiency is expected to be achieved without a large increase in construction costs. The design is complicated by the necessity of guarding against the explosive sodium-water reaction, and of protecting the uranium and graphite from the sodium. Sodium also becomes highly radioactive when irradiated, requiring extra shielding around the heat exchanger.

The reactor building is being completed at the site 30 miles north-west of Los Angeles, and work is in progress on the installation of electric generating plant by the Southern California Edison Company. The turbo-generator, electrical switchgear, transformers and a large water cooling tower are being installed. The steam generator is being fabricated by the Babcock and Wilcox Company and other sodium piping is being fabricated by Atomics International at the site. The delay arose from four different factors. After the reactor core tank was installed it was discovered that the wrong type of welding rod had been used in fabricating the tank and other reactor components. This was due to an error in the works of the welding rod manufacturer. It was necessary to repair or replace all questionable welded items. A second factor was that small cracks developed in the end plates of zirconium cans used for cladding graphite, and the can components had to be re-manufactured. Delivery of the air blast heat exchanger was slowed by fabrication difficulties. It is anticipated that criticality tests will start in January, 1957.

At the Argonne National Laboratory the conceptual design of the Experimental Breeder Reactor No. 2 (EBR-2) was completed during the reporting period and the architectural-engineering phase begun. The new reactor will be sodium cooled, will generate 62·5MW of heat and produce 15MW or more of electricity. It is hoped that the reactor can be in operation in late 1958, although there has been a delay in the schedule. The Zero Power Fast Critical Assembly (ZPR-3) was operated successfully at the Idaho Testing Station during this reporting period. This facility began operation in October, 1955, and will be used to provide accurate data necessary for the detailed design of the EBR-2 core. Critical experiments for the EBR-2 core with uranium 235 are continuing and a plutonium loading for EBR-2 criticality tests will be completed soon. The molten plutonium fast reactor experiment at the Los Alamos Scientific Laboratory is still in the phase of preliminary research and development. Because of health precautions required in experimenting with plutonium, progress is not expected to be rapid. Problems of containing molten plutonium are under investigation and samples are being prepared for irradiation in the Materials Testing Reactor at the Idaho Testing Station.

The construction of Homogeneous Reactor Experiment No. 2 was completed at the Oak Ridge National Laboratory early in May, 1956, together with associated concurrent work on reactor component development. This included testing of a redesigned pressuriser, and a modified pump to circulate the fuel solution. Breaking-in tests are being conducted, and the reactor is expected to become critical this autumn. The power output of HRE-2 probably will not exceed 10MW of heat. Work on the associated chemical processing plant is progressing. HRE-2, like its predecessor HRE-1, is designed to test the economic feasibility and work out the problems of power generation with a reactor in which the fuel is dissolved in a liquid moderator which is circulated as a coolant. HRE-1, which embodied a concept proposed by the Oak Ridge National Laboratory, was dismantled in 1954 after operating successfully for two years at the laboratory. HRE-2 uses for fuel a dilute solution in heavy water of uranyl sulphate, highly enriched in uranium 235. One important advantage of this type of reactor is that the core design is mechanically simple. The reactor has a high degree of nuclear stability which makes for safety. The stability of fuel elements over long periods is not a problem, as in reactors using solid fuel rods. The possibility of continuous removal of fission products, many of which act as neutron absorbers, makes the reactor attractive as a breeder operating on the thorium-uranium 233 cycle. The problem of fuel element stability has been solved, however, at the expense of difficulty in containing the highly radioactive and corrosive solution in a high-pressure plumbing system. Further homogeneous reactor experiments are being conducted at the Los Alamos Scientific Laboratory, where development work continues on aqueous homogeneous reactors using a uranyl phosphate solution and a novel mechanical arrangement.

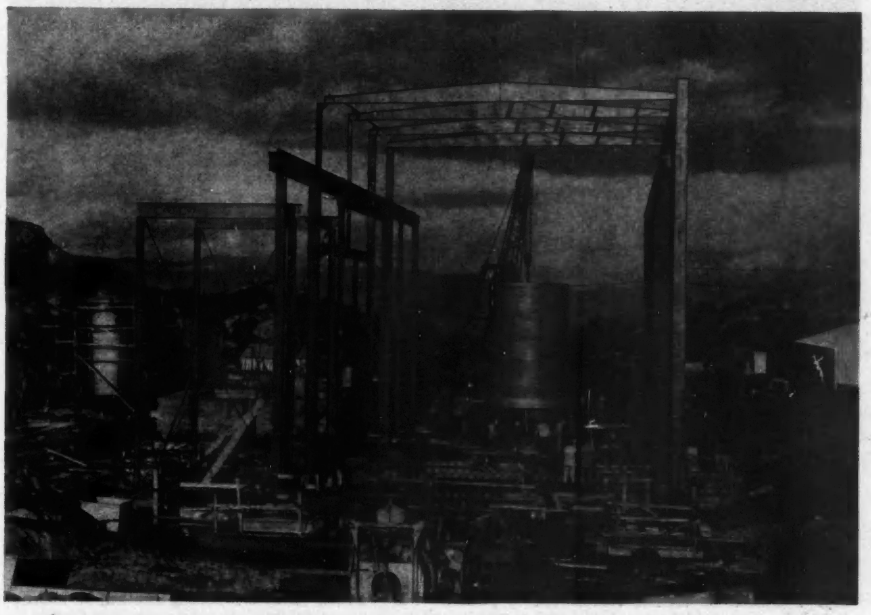


Fig. 3—Construction of the 20MW heat capacity Sodium Reactor Experiment (SRE) by Atomics International at Santa Susana, California, showing positioning of the container housing the reactor core

Naval Reactors

The naval reactors programme, a joint undertaking of the Commission and the Department of Defence, is aimed at developing and evaluating a group of nuclear power plants designed to propel many sizes of naval ships from small submarines to the largest aircraft carriers. The programme continues to be an important accelerating influence on the practical development of all nuclear power plants.

The Submarine Thermal Reactor S1W (formerly STR, Mark 1) plant (Fig. 4) at the National Reactor Testing Station in Idaho is being gradually modified to convert it from a land prototype for the U.S.S. "Nautilus" nuclear propulsion plant into a flexible testing facility, where new developments in technology, design, and operation of improved naval water-cooled nuclear power plants will be investigated, and improved design cores can be tested. The S1W has been redesignated the Naval Reactor Test Facility. The second phase of the modification programme was completed during the winter of 1955–56. This included the installation of a carbon steel steam generator in the primary coolant system, and of improved reactor and primary system control equipment. It also included the partial accomplishment of a change to make the plant capable of operating at higher powers and temperatures. The reactor core and fuel were renewed during that period for the first time, after some thirty months of operation and testing. The U.S.S. "Nautilus," which is powered by the S2W nuclear propulsion plant, formerly the Submarine Thermal Reactor Mark II, now has operated for a year and a half.

Operation of the S1G (formerly SIR Mark A), the land prototype of a nuclear propulsion plant for the submarine "Seawolf" continued at West Milton, New York. It is being used for prototype testing and the training of naval personnel. The U.S.S. "Seawolf," which will be powered by the Submarine Intermediate Reactor, Mark B (S2G), neared completion at the Electric Boat Division in Groton, Connecticut. On April 3rd, the Commission announced that contracts were entered into with the City of Holyoke, Massachusetts, and the Village of Ilion, New York, for the sale of the output of any excess electric power produced by the prototype plant. The two municipalities were given until May 1st to complete arrangements for the transmission of the power from West Milton to their own grid systems. Each was to receive one-half of any excess power. On May 16, 1956, the two municipalities reported that they had been unable to make arrangements to transmit the power. They did not request any extension of time in which to complete their arrangements.

The design and development of the Submarine Reactor (S3G) continued at the Knolls Atomic Power Laboratory. Preliminary grading was completed and the construction of the test site

facilities for the S3G land prototype power plant was put under way. This prototype is being constructed on land adjacent to the S1G land prototype plant at West Milton, New York. Congress authorised the construction of a nuclear powered radar picket submarine in the U.S. Navy's shipbuilding programme for fiscal year 1956. This submarine, to be powered by two S3G nuclear reactors, will be the largest submarine ever built, and the first powered by two reactors.

Army Reactors

The Army reactors programme, intended to develop reactor systems for special military needs, now includes three major projects—the Army Package Power Reactor, the Argonne Low Power Reactor, and the Food Irradiation Reactor. Preliminary steps also are being taken toward the eventual development of gas-cooled power reactors for special military and civilian applications.

The construction of the Army Package Power Reactor APPR–1 (Fig. 5) continued during the past six months at Fort Belvoir, Virginia. The major portion of the building and the vapour container were finished, and some non-reactor equipment was installed under the supervision of the prime contractor, Alco Products, Incorporated. The plant, which is scheduled for operation early in 1957, is intended to produce 1825kW of electricity. Development work supporting military pressurised water systems continued with the completion of critical experiments by the Oak Ridge National Laboratory. Heat transfer tests at Columbia University, and fuel element development projects under contracts with the Nuclear Development Corporation of America and Sylvania Electric Products, Incorporated, are still in progress.

The Pioneer Service and Engineering Company was selected under sub-contract with the Argonne National Laboratory for the design of the non-nuclear portions of the Argonne Low Power Reactor. The project, which was established in November, 1955, calls for the development of a boiling water heterogeneous reactor power plant for military use. The net power output would be 200kW and the reactor will be constructed at the National Reactor Testing Station.

At the request of the Department of Defence, the Commission initiated a project to provide a food irradiation source for the Army Quartermaster Corps. During this reporting period, experiments were continued to demonstrate whether foods sterilised by this process would be non-toxic, acceptable to consumers, adaptable to efficient handling techniques, and economically competitive with foods preserved by other processes. Joint studies by the Commission and the Department of Defence concluded that a reactor arranged for gamma ray production should meet the Army's food irradiation requirements. Conceptual design studies were made of various reactor designs to form a basis for selecting the best system. In connection with designing gas-cooled power reactors to meet military needs for compact, water-free power systems, and civilian requirements for an economic small power station, the Battelle Memorial Institute has begun testing materials applicable to this reactor concept. The preliminary design of gas-cooled test loops has been initiated, and a contractor is being selected to design, construct, and operate a gas-cooled reactor experiment.

Aircraft Reactors

During this reporting period research and development activities on aircraft nuclear power plants progressed satisfactorily. In April the Commission entered into a contract with the Ralph M. Parsons Corporation of Los Angeles, for the design of new test facilities to be built in the Aircraft Nuclear Propulsion area of the National Reactor Testing Station. The contract calls for designing a test building, a shielded control and equipment building, and supporting facilities. Design work under the contract is expected to be completed in about ten months, with construction expected to start in the spring of 1957. Construction is estimated to cost approximately 12,000,000 dollars, and as many as 600 workers may be employed on construction. As the design and construction agent of the U.S. Air Force at the Idaho Station, the Commission entered into a contract in February, 1956, with Porter, Urquhart, McCreary and O'Brien, of San Francisco, California, for the design of a runway and auxiliary facilities to be constructed at the testing station.

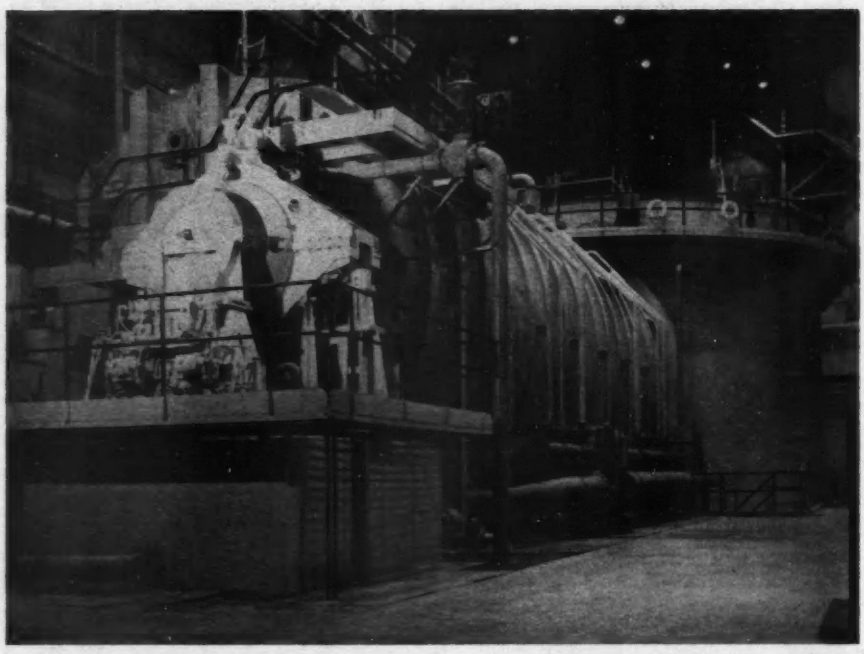


Fig. 4—Submarine thermal reactor (S1W) plant at the National Reactor Testing Station in Idaho; it is being converted from a land-based propulsion pilot plant to a flexible "Naval Reactor Test Facility"

General Engineering and Development

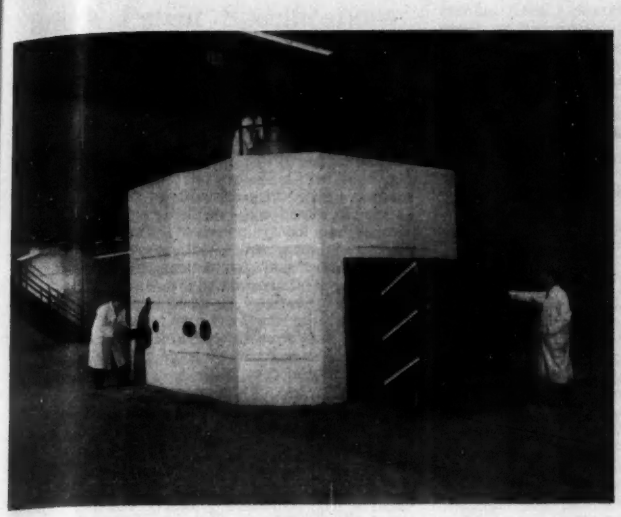
During the last six months, the Atomic Energy Commission has asked private industry to undertake chemical processing, has signed contracts for increased commercial production of zirconium, and invited proposals on reactor materials currently being produced in Government-owned facilities. In addition to these moves to encourage wider participation in the atomic energy industry, the Commission has set prices and begun to market certain basic reactor materials; has held a conference on homogeneous reactor design and building (Fig. 6); has undertaken studies on pressure vessel stresses and proposed a study of safety codes governing pressure vessels; has moved ahead with possible commercial applications of nuclear heat; and has assigned top priority to the construction of the Engineering Test Reactor urgently needed to carry on irradiation tests of power reactor components. Research has been conducted on various methods of separating fission products and reprocessing spent fuel elements, on waste disposal, and on reactor safety.

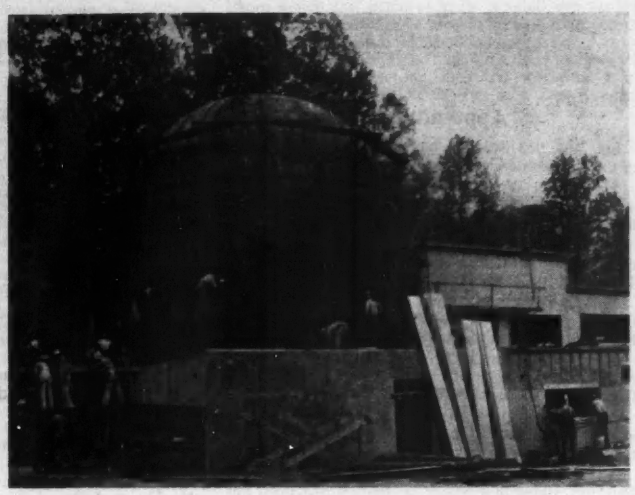
A policy aimed at having commercial chemical works ready to process spent fuel elements from the first privately-owned power reactors was announced by the Commission on January 5, 1956. It was discussed later in the month at a chemical processing meeting at Idaho Falls, Idaho, attended by 183 representatives of business firms. The talks centred on the effect of cost factors in chemical processing on the economical operation of reactors. It was announced that proposals would be invited some twelve to eighteen months later for the design, construction and operation of the chemical processing plants. The Commission would permit the use of its laboratories on a reimbursable basis for developmental work by those whose proposals were accepted, and would supply the plants with an initial base load of spent fuel from one or more of perhaps twenty reactors. Meanwhile, interested firms will be furnished with samples of spent fuel elements and information on technology, fuels available, costs, &c., to help them prepare proposals.

The Commission has urged private companies to take over the production of lightweight engineering materials for use in reactor and accelerator shielding. The decision was prompted by an increasing interest by business concerns in the manufacture of boral—a solidified mixture of boron carbide and aluminium originally produced at the Oak Ridge National Laboratory. During this reporting period, the Brooks and Perkins Company accepted two orders for boral from private firms.

In May the Commission announced an expanded programme for the procurement of high-purity zirconium metal and hafnium oxide to meet increasing short and long-range reactor development requirements. A major portion of the procurement is for scheduled projects of the U.S. Navy; the remainder is for the Commission. To provide an assured future supply of the materials, long-range contracts have been signed with three new commercial suppliers who were among ten firms which submitted proposals. These three contracts, covering a five-year period, call for the annual delivery of 2,200,000 lb of zirconium, at an average cost of about 14,000,000 dollars a year. The new long-range suppliers are: The National Distillers Products Corporation, which will supply 1,000,000 lb annually from new facilities to be constructed at Ashtabula, Ohio, the N.R.C. Metals Corporation, a subsidiary of the National Research Corporation, Cambridge, Massachusetts, which will supply 700,000 lb annually from a plant to be constructed near Pensacola, Florida; and the Carborundum Metals Corporation, which will supply 500,000 lb annually from a plant to be constructed at Parkersburg, West Virginia. The contracts are for fixed unit prices subject to revision within established ceilings at specified periods during the contract terms. Production is expected to begin late in 1957 from the new plants to be financed entirely by the suppliers.

Three proposals were received in May in response to the Commission's invitation to private industry to submit proposals for supplying up to 100,000 lb a year of reactor-grade beryllium metal over a five-year period. The proposals came from the Brush Beryllium Company, the Beryllium Corporation of America, and the Riverside Metals Company. The three proposals will be evaluated technically, and the plants inspected before a decision is made. Beryllium requirements now are met from the





Figs. 5 and 6—(Left) Construction of the 1825kW capacity Army Package Power Reactor (APPR-1) of pressurised water design by Alco Products at Fort Belvoir, Virginia, showing the finish site welding of the vapour container. (Right) 50kW homogeneous solution reactor constructed by Atomics International for the Armour Research Foundation in Chicago for private industrial research applications

production of a Government-owned plant at Luckey, Ohio, which is operated for the Commission by the Brush Beryllium Company. If the proposals prove acceptable, the Luckey plant would be placed on a stand-by basis.

An unclassified feasibility study of pressure vessels for nuclear power reactors was published in December, 1955, by the Commission and is presently available to industry. Through the Pressure Vessel Research Committee of the Engineering Foundation, the Commission is sponsoring an investigation of the stresses at nozzles and openings of pressure vessels in order to provide the facts on stress concentrations in those areas. The results of the study may justify the use of lower safety factors in pressure vessel design with resultant savings in materials. Pennsylvania State University is conducting this study under contract. The Engineering Foundation's Welding Research Council will inform industry of the results through publications of the Council. At present the Boiler and Pressure Vessel Code of the American Society of Mechanical Engineers, or a local version of that code, constitutes the legal basis for the design of boilers and pressure vessels in the key industrial states of America. The National Board of Boiler and Pressure Vessel Inspectors, consisting of the chief inspectors from the various states and cities, is charged with the administration of the code. While this code has proved adequate in providing safe construction for conventional boilers and pressure vessels, additional provisions will be necessary in designing vessels for reactor service. In addition, certain of the code's present provisions would introduce unnecessary hazards if imposed on reactor vessels. In view of these facts, the Commission has been instrumental in organising a special sub-committee of the Boiler and Pressure Code Committee on Nuclear Power. This special sub-committee will co-operate in modifying the code to provide for nuclear requirements, and will eventually prepare an additional section to the code applying specifically to nuclear installations. In addition, the membership of the Non-Ferrous Sub-Committee has been enlarged to include engineers qualified to prepare industrial standards specifications and develop allowable design data for certain newer structural materials useful in nuclear installations.

The construction of the Engineering Test Reactor (ETR) went ahead on a top priority basis during this reporting period at the National Reactor Testing Station. The ETR will provide irradiation facilities urgently needed in developing reactor components for military and civilian power reactors. The completion and initial operation of the facility is scheduled for March, 1957. General design and construction were undertaken by the Kaiser Engineers Division of the Henry J. Kaiser Company. Nuclear design of the reactor core and facilities within the tank is being performed by the Atomic Power Equipment Department of the General Electric Company under contract to Kaiser and the fuel elements are being designed by the Oak Ridge National Laboratory. To make the reactor available for experimentation as early as possible, some facilities designed to handle the first experiments are being constructed and installed at the same time as the reactor structure itself.

The Westinghouse Electric Corporation began construction in September of the first large testing reactor to be built by private industry. Completion is scheduled for August, 1957. The plant, to be known as the Westinghouse Testing Reactor (WTR), will be situated on an 800-acre site near Waltz Mill, Pennsylvania, 29 miles south-east of Pittsburgh. The WTR will be used for the evaluation of full-size fuel specimens and other components of atomic power plants under actual operating conditions. Using highly enriched uranium with light water as a moderator and coolant, the reactor will operate in the range of 20MW or above.

During this reporting period initial tests to determine the feasibility of using nuclear heat to produce gas from coal were begun at the Appalachian Experiment Station at Morgantown, West Virginia, of the Bureau of Mines, U.S. Department of the Interior. The tests, which do not use actual nuclear heat, resulted from discussions between the Bureau and the Commission regarding the applicability of nuclear heat to high-temperature chemical processes. The Bureau undertook to build two experimental units, heated electrically, as models of possible future nuclear units. The first model has been built and is being used in current tests at Morgantown; the second is scheduled for early completion. In co-operation with the Bureau of Mines, the Commission initiated a preliminary engineering study to determine the feasibility of a process heat reactor. It is expected that this reactor would operate in a temperature range of 1370 deg. Cent. It is anticipated that this study will point up the need for work aimed at developing components which will operate satisfactorily at high temperatures. This reactor concept has been followed with great interest by industry, since it has potential application to other high-temperature chemical processes.

In the field of chemical engineering the Commission laboratories and contractors continued with research and development programmes dealing with the separation of fission products from spent fuel elements. The separation methods under study included gasification of fuel elements combined with fractional distillation; liquid metal extraction; evaporation of fission products from molten metal, from solids, and by flash distillation in arc zones. Solid scavenging techniques and fused salt extraction have also been tested. In addition, work in pure metallurgical processing was stepped up to implement the process data needed for reactors such as sodium graphite reactors and fast breeder reactors.

A new separation process being developed at the Argonne National Laboratory is based on the fluorination of reactor fuel elements, followed by fractional distillation of the fluoride products. Successful tests of the process have been carried out on a pilot plant scale. The Oak Ridge National Laboratory has also done research on the fluoride volatility process, dissolving uranium in molten fluorides and then generating uranium hexafluoride which volatiles readily. The process is simpler and cheaper than conventional solvent extraction methods.

Another new processing concept—called pyrometallurgical processing—being developed by Argonne, by the Ames Laboratory in Iowa, and by Atomics International, a division of North American Aviation—has as its objective not complete purification, but sufficient purification to permit re-use of fuel in a reactor. The Argonne effort is directed toward a specific type of nuclear reactor—the fast reactor. At the high neutron energies existing in these machines, the effect of fission products on neutron economy is much less than in thermal reactors. Repurification is therefore needed primarily to maintain the radiation stability of the fuel. Sufficient purification may be effected by simple chemical and metallurgical techniques similar to those now employed with such metals as steel, copper, zinc, and lead. When a satisfactory process is developed it will be tried out as part of the operation of the Experimental Breeder Reactor No. 2, now under design at Argonne. The molten metal extraction method of reprocessing reactor fuel, as studied at Ames, keeps the metal in its metallic state and so does away with dissolving the fuel metal in acid and using aqueous solution chemistry for purification. This procedure involves melting uranium and uranium alloy with another metal. The separation of uranium takes place with a concurrent separation of fission products. The uranium then can be recast into fuel elements and put back into the reactor until another reprocessing is necessary.

A similar process being investigated by Atomics International places the uranium melt in contact with a molten metal, such as magnesium, at a temperature above the melting points of both metallic phases. Magnesium has successfully separated plutonium and some fission products from irradiated uranium metal by direct solvent action at 1150 deg. Cent. Three other high temperature chemical processing methods have been under investigation at Atomics International. Direct distillation of plutonium and of many fission products from irradiated uranium metal can be achieved at temperatures of 1600 deg. to 1700 deg. Cent. The more volatile fission products and some uranium have been separated from irradiated thorium-uranium metal by (1) evaporation from molten metal, (2) vaporising from solid samples, and (3) flash distillation in the arc zone of an arc melting apparatus.

(To be concluded)

Personal and Business

Appointments

SIR WILLIAM STANIER has been elected president of the Engineers' Guild.

MR. PETER WICKINS has joined the outside sales staff of Safety Products, Ltd., Holmethorpe Avenue, Redhill, Surrey.

MR. TERENCE PARKER has been appointed a director of Andrews Toledo, Ltd., and Andrews Toledo (Wire Rod), Ltd.

MR. C. F. HUEBNER, chief buyer of British Oxygen Company, Ltd., has been elected chairman of the Purchasing Officers' Association.

MR. D. A. M. LEWIS has been appointed joint managing director of Farnborough Engineering Company, Ltd., Farnborough, Kent.

MR. J. W. RIDLEY has been appointed sales manager of British Physical Laboratories, Ltd., and Quadrant Meter Company, Ltd., Radlett, Herts.

A. REYROLLE AND CO., Ltd., Hebburn, Co. Durham, states that Mr. P. J. Fell, A.M.I.E.E., has been appointed district manager of the Nottingham office in succession to Mr. W. B. Fenwick.

DR. KURT BILLIG and Mr. HARRY R. RODGERS have accepted appointments from the United Nations Technical Assistance Administration to advise on the development of water resources in Pakistan.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, states that Mr. S. Crosbie, A.M.I.E.E., has been appointed assistant chief engineer in the railway signals department.

LONDON TRANSPORT has announced the following appointments in the chief civil engineer's department: Mr. H. G. Follenfant, M.I.C.E., assistant civil engineer (permanent way), and Mr. A. C. Edrich, A.M.I.C.E., assistant civil engineer (general).

MR. MARK H. PHILIPS, personnel director of the Heenan group of companies, has been appointed to the board of the holding company, Heenan Group, Ltd. Mr. C. M. A. Whitaker has been appointed a director of Fielding and Platt, Ltd., one of the companies in the Heenan group.

Business Announcements

BRITISH OXYGEN GASES, Ltd., has opened a new factory at Castlereagh, Belfast.

Q.V.F., Ltd., states that it will shortly move to new premises at Fenton, Stoke-on-Trent.

LORD CHANDOS, chairman of Associated Electrical Industries, Ltd., is visiting Norway and Sweden.

GEORGE COHEN, SONS AND CO., Ltd., states that its title is being changed to the George Cohen 600 Group, Ltd.

WONTOOLS, Ltd., has moved its offices and stores to 117, Stafford Road, Wallington, Surrey (telephone, Wallington 1839).

MR. R. F. GALBRAITH, M.I.Struct.E., has moved his office to Cromwell House, Fulwood Place, London, W.C.1 (telephone, Chancery 2067).

WOLF ELECTRIC TOOLS, Ltd., states that an agreement has been made with Rallis India, Ltd., Bombay, for the production of Wolf electric tools in India.

THE EXPORT CREDITS GUARANTEE DEPARTMENT has opened a new office at Block 5, Government Buildings, Chalfont Drive, Nottingham (telephone, Nottingham 77711).

FORTH CHEMICALS, Ltd., states that the expansion of its styrene monomer plant at Grangemouth, Scotland, has been completed and will come into operation this month.

STEELS ENGINEERING INSTALLATIONS, Ltd., states that its home and overseas sales office has been moved to 143, Sloane Street, London, S.W.1 (telephone, Sloane 6178; telegrams, "Steelascos, Knights, London").

KEELAVITE ROTARY PUMPS AND MOTORS, Ltd., Allesley, Coventry, states that Mr. G. V. Keeling, chairman and managing director, Mr. F. B. Levetus, technical director, and Mr. N. Lee, technical manager, are visiting the U.S.A.

THE EXPANDED METAL COMPANY, Ltd., Burwood House, Caxton Street, London, S.W.1, states that Colonel Arthur Hodge is retiring from the sales staff after thirty-four years' service. He will continue to act as a consultant to the company.

THE LANCASHIRE DYNAMO GROUP has announced the formation of a new company entitled Lancashire Dynamo Nevelin, Ltd., which is to take over the activities of the Nevelin Electric Company, Ltd., and Lancashire Dynamo Switchgear, Ltd. Mr. H. W. Bosworth is the chairman, and Mr. A. Newing, managing director of the new company.

Miscellanea

TURBINE TRANSPORT.—Sir W. G. Armstrong Whitworth Aircraft, Ltd., is to manufacture a number of pressurised medium range aircraft for freight or passenger coach services. Rolls-Royce engines, four "Dart" propeller turbines or two more powerful units will be used. The range will be about 2000 miles and the payload up to sixty-six passengers.

PETROL-PROOF APRONS.—Large aprons of polyvinyl chloride sheet have been made for the Ministry of Supply by Plysec Products, Ltd., Woburn Sands. They are intended to safeguard petrol used in tanks of up to 30,000 gallons capacity when impact or other tests are made. The aprons, in use, are draped in and over the sides of a sand-bagged emplacement, within which is the test tank. The material is "Vybak" V.B. 177 of 0·020in thickness, welded at radio frequency into sheets 120ft by 30ft and weighing nearly 10 cwt each. This material is made by Bakelite, Ltd., using a polymerin plasticiser to resist the solvent action of petrol.

SLOTTED ANGLES.—Particulars have been received of two new slotted angles for general structural use, introduced by Dexion, Ltd., 65, Maygrove Road, London, N.W.6. No. "140" is a slotted angle with equal flanges, 1¼in by 1¼in, whilst No. "112" is a half size version, 1¼in by ¾in, of the already established No. "225," and is the smallest in the range. Slotting is arranged to cover as many different applications as possible and both the new angles are designed to bolt together with all others in the range. These angles are available in steel, which is rust protected and stove-enamelled battleship grey, or in aluminium alloy.

FILMS.—"Water—Friend or Foe" is the theme of two new colour films recently completed by the Yorkshire Copper Works, Ltd., which were shown before an invited audience in London last week. The first film, "Yorkshire-on-Thames," deals with the history of corrosion problems and traces the development of copper and copper-base alloys to meet new operating conditions in modern plant. It illustrates the research and investigation necessary to determine the most suitable alloy to be employed for piping in a variety of industries. "The 'Yorkshire' Way with Water" has a similar theme, but deals with pipelines carrying water purely for domestic uses. Many aspects of modern plumbing and pipelaying are covered and, in addition to the use of copper tubes and metal fittings, the increasing use of plastic tubes and fittings is demonstrated. These films are available in 16mm size.

IRRADIATED PLASTIC TAPES.—A range of irradiated polythene tapes, which has been developed by Tube Investments, Ltd., is stated to have many potential applications in the electrical and packaging industries. In manufacture, the polythene, following exposure to high energy radiation, is converted from a thermoplastic melting at 113 deg. Cent. to a material which acquires rubbery characteristics above this temperature, and has, in fact, no definite melting point. While the tape remains intact, its tensile strength falls at high temperatures, but the limiting temperature is of the order of 130 deg. Cent., compared with 70 deg. Cent. for unirradiated tape. The tape can be elastically deformed at temperatures above 100 deg. Cent. and retains the new shape after cooling. Subsequent reheating will cause it to revert to its original shape. Chemically, the tape closely resembles ordinary types of polythene, but has somewhat better solvent, acid and oil resistance. Electrically, the power factor may be slightly reduced, but the breakdown strength is increased. Mechanical properties are slightly improved and heat sealing is still possible, though the bond is somewhat weaker than with ordinary polythene. To ensure complete stability, the tape has an anti-oxidant incorporated, and the conditions of radiation are so chosen that no residual radioactivity is left with the film. We are informed that up to the present, production has not gone beyond the pilot stage, but specimen lengths are available for testing.

THE 2,000,000TH VILLIERS ENGINE.—On September 26th we attended a ceremony at the works of Villiers Engineering Company, Ltd., Marston Road, Wolverhampton, when the two-millionth engine to be produced there came off the assembly line. This engine, a Villiers Mark 1H, 225 c.c. petrol engine, was immediately taken to the test house, and later in the day fitted to a Francis-Barnett Cruiser motor-cycle. In a few weeks' time, the engine is to go to the Science Museum, South Kensington, to which it has been presented by the makers. It is interesting to recall that Villiers Engineering Company, Ltd., began to build engines forty-four years ago, the first to be produced being a four-stroke motor-cycle engine of 350 c.c., with an integrally mounted two-speed gearbox, friction clutch, overhead inlet valve and side exhaust valve. A motor-cycle fitted with the engine lapped Brooklands at 46 m.p.h., but the firm say that British motor-cycle makers considered the engine to be "too advanced!" The firm then turned its attention to two-stroke engines, but in more recent years has again revived the production of four-stroke engines as well. At the same time, its activities have not been restricted to the manufacture of motor-cycle engines; its products now have many applications to a variety of agricultural and industrial machines. In the forty-four years of engine production the firm's factory area has been extended from half an acre to 17 acres and its labour force from twenty to over 3000.

RECONSTRUCTION OF CROMWELL WEIR ON THE RIVER TRENT.—The British Transport Commission's waterways division has announced details of a further scheme in its £5,500,000 development plan for the principal inland waterways. Cromwell Weir, some 5 miles downstream from Newark on the River Trent, is to be reconstructed at a total cost of over £250,000. This is the first weir on the River Trent and is the limit of tidal influence. The existing structure, which dates from 1911 and is basically of concrete bag construction, was severely damaged by floods in January, 1955. Emergency repairs were immediately undertaken to retain the river level necessary for navigation until plans could be drawn up for its reconstruction. The new weir, we are informed, will be considerably larger and stronger than the existing structure and will be curved "in order to divert the main force of water from the downstream approach to the lock and from the right bank." The construction will be of mass concrete with rows of steel sheet piling on both sides, with a substantial right bank abutment extended by a containing wall both up and downstream to ensure that the river will not by-pass the new weir. Supplementary works will include a downstream extension to the lock guide wall, some steel sheet piling on the left bank, and an approach road to the site from the village of Holme on the right bank. A scale model of the new weir, constructed at the British Transport Commission's Research Laboratory, has been subjected to flow experiments with satisfactory results. The consulting engineers are Messrs. Coode and Partners, London, and the work will be carried out by A. Monk and Co., Ltd.

BY-PASS ENGINES.—The Summer, 1956, issue of the *Bristol Quarterly*, includes an engrossing study of aircraft propulsion entitled "Pure Jet *v.* By-Pass." The augmentation ratio, by-pass flow/combustion flow, has seldom been taken far beyond unity in analysis; this article shows why, since a 2·5 by-pass ratio in an engine as small as 10,000 lb thrust might involve 150 h.p. frictional losses and therefore 120 lb cooling drag. At the more commonly considered ratio of 0·6, engines of the same mass flow, thrust, and pressure ratio show that specific fuel consumption is 2 per cent better for the pure jet when cruising at altitude. This figure allows for variations in the specific heat of air (the turbine inlet temperature of the by-pass is over 200 deg. Fah. higher) and assumes 1·5 per cent loss due to air cooling of turbine blades in the by-pass engine only. These results appear to confirm earlier predictions of by-pass economics. The article does not go beyond the performance of the engine to that of the airframe, and does not, therefore, introduce the question of engine weight. Another study based on identical low-pressure compressors in two engines with by-pass ratios 0 and 0·5 showed the pure jet to be about 20 per cent greater in installed weight, as a result of the scaling down of the high-pressure components of the by-pass engine. The assumptions promulgated, together with the fairly mild slope of curves plotted against by-pass ratio, suggest that these two cases are approximately comparable. Thus, it would appear that the percentage loss in specific fuel consumption will be balanced by a gain in power plant weight about eight times as great; this will clearly favour the by-pass for medium or even some long range flights. The additional merits claimed for the protagonists are greatly improved reliability in the low temperature engine and around 6 decibels less noise from the by-pass; this last claim is not discussed in the article, probably because the noise nuisance can be greatly minimised by aircraft climbing out fast and steeply. The same issue contains a description of the test plant for ramjet engines, in which the present 18,000 compressor h.p. are to be supplemented by ejectors running from a reservoir of steam at 200 lb per square inch. The final article deals with the manufacture of rocket motor cases from sheet steel, which by Argon-arc welding and subsequent stretch forming achieves ultimate strengths of 75 tons to 85 tons in both metal and weld on the final fully-machined product.

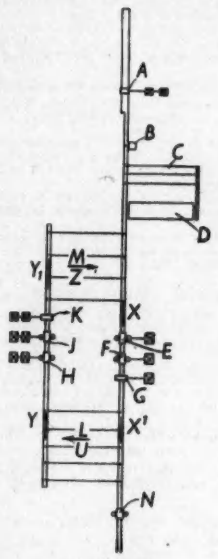
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

METALLURGY

756,259. July 7, 1954.—ROLLING THIN PROFILE SECTIONS, Maschinenfabrik Sack G.m.b.H., Dusseldorf-Rath, Germany.

The invention relates to a rolling mill for rolling profile sections, especially "I"-profile sections, in which the material is shaped so rapidly in a comparatively small number of stands in which the direction of rotation of the rolls remains unaltered, that the work does not cool down to an undesirable extent. By this means the advantage of continuous rolling is obtained. Referring to the drawing, *A* is a preliminary rolling stand and *B* a shearing device. After the shears is a transverse conveyor *C* and a heating-up furnace *D*. Two universal reducing stands *E* and *F* operate in succession, the relative speed of rotation of the rolls of the two stands depending on the amount of reduction. A two-high upsetting stand *G* is used for upsetting and smoothing the flanges of a profile iron, for example, an "I"-profile, the thickness of which and also that of the web was reduced by the rolls of the stands *E* and *F*. The direction in which the work passes through the



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rolls is indicated by the arrows *X*—*X'*. The stands *H* and *J*, which are arranged to one side of the stands *E* and *F*, are also universal reducing rolling stands. They are again followed in the direction of rolling *Y*—*Y'* by an upsetting stand *K*. The conveyor devices *L* and *M* move the rolled material in the directions *U* and *Z*, respectively, as indicated by the arrows. It will be seen that an upsetting pass follows each two reducing passes, and that the direction of rotation and the speed of all the rolls of the stands *E* and *K* remains unaltered, and that if the work is passed twice through the group of stands *E* to *G* and once through the group of stands *H* to *K*, six reducing and three upsetting passes are carried out, whereas if the work is passed three times through the group of stands *E* to *G* and twice through the group of stands *H* to *K*, ten reducing and five upsetting passes are altogether carried out. The finishing of the profile section takes place in a single passage through the universal finishing stand *N*. The rolling mill of the invention permits higher rolling speeds so that the time required for rolling is reduced, whereas with purely continuous rolling the speed of passage through the rolls can be only small during the first passes. Also, since no gear is required, the time necessary for rolling is considerably reduced. The rolling mill of the invention and the rolling method which can be carried out by it, therefore, enable the final dimensions of the work to be smaller and girders having a better relationship between carrying power and weight can be produced.—*September* 5, 1956.

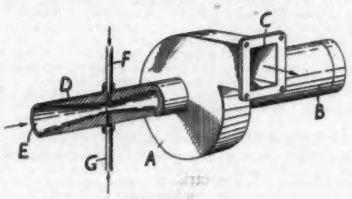
757,081. May 7, 1953.—THE TREATMENT OF METALS, Diffusion Alloys, Ltd., 18, Maddox Street, London, W.1. (*Inventor: Robert Lionel Samuel.*)

The invention is particularly concerned with the formation of a film of one metal on the surface of another metal. According to the process, a high-speed or air hardening steel having a secondary hardening range of up to 620 deg. Cent., or an alloyed steel having a tempering range of up to 620 deg. Cent., is heated in the presence of a heat-dissociable iodide of the coating metal at a temperature of between 200 deg. and 650 deg. Cent. until a film of the coating metal is formed on the surface of the steel to be coated. The dissociable iodide of the coating metal may be formed in the reaction chamber in which the reaction is taking place and is dissociated on contact with the steel to be coated. If desired, the process may be carried out in the presence of a reducing agent. Examples of preferred coating metals are chromium, molybdenum, tungsten, vanadium, silicon and aluminium. Preferably the pressure is atmospheric or only slightly above or below atmospheric. The term "metal" as used includes silicon and also alloys. The following example, in which the percentages are by weight, illustrate the invention. A number of fully heat-treated drills made of steel containing 18 per cent of tungsten were packed in contact with chromium powder, to which was added 0·5 per cent of urea and 0·05 per cent of iodine. The steel box containing the articles and the powder was sealed with a refractory cement covered with a fusible heat-treatment salt. The box was heated to a temperature of 560 deg. Cent. for twelve hours. On removal from the box, the drills were found to be of a greenish-black colour. Their surface hardness was considerably higher than before treatment. Chromium could be chemically detected on the surface, although the coating was too thin to be easily detected by micro-examination. The performance of the drills was far superior from the point of view of cutting efficiency to that of the untreated tools. Similar results were obtained when the example was repeated, using 0·1 per cent of iodine instead of 0·05 per cent.—*September* 12, 1956.

MEASURING INSTRUMENTS

756,380. December 8, 1953.—GAS SAMPLING APPARATUS, Kelvin and Hughes, Ltd., Kelvin Works, Kelvin Avenue, Hillington, Glasgow, S.W.2. (*Inventor: Alfred James Graham Milne.*)

The invention relates to gas systems and more particularly to means for extracting a comparatively small stream of gas from a main gas stream for testing, such as the apparatus known as gas analysers. As will be seen from the drawing, a centrifugal fan *A* is driven by an electric motor *B*. The fan outlet *C*



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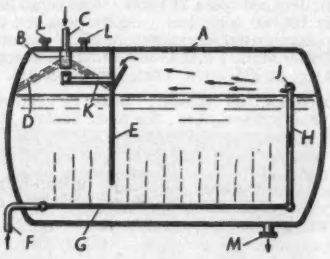
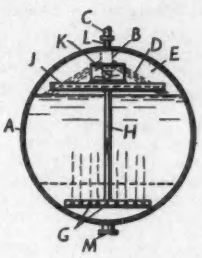
is open to the atmosphere and the intake is connected to a venturi tube *D*, the inlet end *E* of which is open to the atmosphere. A small bore tube *F* is connected to the throat of the venturi so that the test sample of gas can be drawn off by the suction through the tube. If desired, one or more additional tubes *G* may be connected to the throat of the venturi tube. Modified designs and applications are also shown in the specification.—*September* 5, 1956.

STEAM GENERATORS

756,820. October 12, 1954.—APPARATUS FOR DEGASIFYING BOILER-FEED WATER, Koninklijke Machinefabriek Gebr. Stork and Co. N.V., Hengelo (O), Holland.

The invention relates to an apparatus for removing gas from water under a pressure above atmospheric, particularly from boiler-feed water, the apparatus comprising a horizontally disposed vessel, in which near one of its ends, a spraying device for supplying the water to be degasified is arranged above the water level in the vessel and discharges the water in the form of a screen, the vessel being provided with means for supplying steam and with a gas outlet above the screen. The invention has for its object to avoid the discharge of steam below the water level in the vessel under all circumstances and still to obtain an efficient deaerating of the water by transmission of convention heat. As shown in the drawing, the top of the vessel *A* has at one of its ends a spraying device *B* to which the boiler-feed water to be deaerated is supplied at *C*, to be sprayed into the vessel in the form of a conical screen *D*. The compartment of the vessel, in which the water cone *D* is formed, is separated from the remaining part of the vessel by an upright partition *E* extending below the water level. The steam is supplied to the vessel by a conduit *F*, to which a set of tubes *G* is connected, from which the steam ascends through the vertical tube *H* to the discharge pipe *J*, to be discharged on substantially the full width of the water level. In the first compartment of the vessel a tube *K*, above the water level, has one end open and connected to an opening in the partition *E*. The tube *K* at its other





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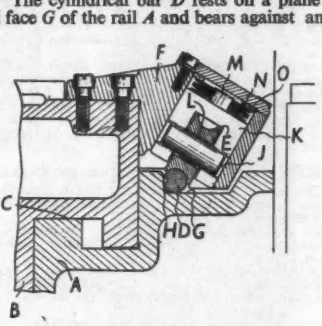
end opens below the spraying device *B*, so that the steam and the gases from the right-hand compartment of the vessel are discharged below the water screen and pass through the screen to the outlets *L*. The steam flowing through the set of tubes *G* heats the water in the lower part of the vessel, so that the gases still contained in the water are driven out and ascend in the space above the water level, where the gases are carried away by the steam blowing out of the tube *J*, to be discharged below the water screen. The vessel is provided with an outlet *M* for the deaerated water.—*September* 12, 1956.

MACHINE TOOLS

756,305. November 16, 1954.—THE MOUNTING OF CARRIAGES, Société Anonyme des Anciens Etablissements Charles Berthiez, 5 Rue Montalivet, Paris (8eme), France.

The invention relates to the mounting of carriages for machine tools and comprises a device which uses a particular form of roller track and roller. As will be seen *A* is a horizontal rail of a planing machine having two vertical pillars. A carriage *B* designed to carry the tools can slide on this rail along the slides *C*. On the upper rear portion of the rail *A* a cylindrical bar *D* is arranged parallel to the slides. On this cylindrical bar rolls a roller *E*, resiliently mounted in a box *F* fixed on the carriage by a bracket on the upper face of the carriage. The cylindrical bar *D* rests on a plane horizontal face *G* of the rail *A* and bears against another



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vertical plane face *H* under the action of the roller. The box in which the roller is mounted has a cylindrical bore *J* in which a piston *K* can slide. An axle fitted transversely in the piston supports the roller through a needle bearing *L* in such a manner as to allow the roller to undergo, if necessary, slight axial displacements. The upper portion of the piston is provided with a centring boss *M* on which is mounted a pile of strong, resilient washers of the "Belleville" type. This pile of washers bears on the one hand on the upper face of the piston *K*, and on the other hand on the inner face of a cover *N*, through an intermediate rigid regulating washer *O*. The "Belleville" washers force the roller against its roller track constituted by the cylindrical bar.—*September* 5, 1956.

Launches and Trial Trips

KAIMAI, coaster; built by Henry Robb, Ltd., for the Union Steam Ship Company of New Zealand; length between perpendiculars 250ft, breadth moulded 41ft 6in, depth moulded to upper deck 17ft 9in; deadweight 2100 tons on 16ft mean draught, designed speed 11 knots; four cargo holds, capacity 106,000 cubic feet; electric winches, three 114kW diesel-driven generators, one 25kW generator; Clark Sulzer Mark T.P.D.48 two-stroke diesel engine, 1500 b.h.p. at 225 r.p.m. Trial, September 5th.

VOLVATELLA, oil tanker; built by Hawthorn Leslie (Shipbuilders), Ltd., for Shell Tankers, Ltd.; length overall 660ft, breadth moulded 84ft 3in, depth moulded 46ft 3in, deadweight 32,200 tons; thirty cargo oil tanks, one main pump room, four vertical centrifugal turbo driven cargo pumps, two 550kW 450V 60 c/s turbine-driven alternators, one 150kW diesel-driven alternator; one set of double-reduction geared turbines, 14,500 s.h.p., takes steam at 600 lb per square inch and 850 deg. Fah. from two Babcock and Wilcox boilers. Launch, September 5th.

MERCHANT ROYAL, cargo ship; built by the Blythswood Shipbuilding Company, Ltd., for the Drake Shipping Company, Ltd.; length 470ft, breadth 63ft 2in, depth to upper deck 41ft 6in, draught 27ft 6in, deadweight 11,500 tons, loaded trial speed 15½ knots; two complete decks, five holds, one 30-ton and ten 10-ton derricks, electric winches; two 160kW diesel-driven generators, two 80kW steam-driven generators; Rowan-Doxford, two-stroke diaphragm engine, five cylinders 700mm diameter by 2320mm combined stroke, 6200 b.h.p. Launch, September 6th.

CORSTAR, self-trimming collier; built by the Burntisland Shipbuilding Company, Ltd., for William Cory and Son, Ltd; length between perpendiculars 320ft, breadth moulded 46ft, depth moulded 22ft 4in, draught 20ft 2in, deadweight 4670 tons; five holds, electric deck machinery, three 75kW diesel-driven generators; Clark-Sulzer single-acting, two-stroke diesel engine, six cylinders, 1300 b.h.p. at 162 r.p.m. Trial, September.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Oct. 5th.—LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "The Modern Police Force," Chief Inspector Collins, 7.30 p.m.

Mon., Oct. 8th.—CENTRAL LONDON BRANCH: White Hall Hotel, Bloomsbury Square, W.C.1, "Relays and Automatic Control in Industry," W. L. Stern, 7.30 p.m.——N.W. LONDON BRANCH: Century Hotel, Forty Avenue, Wembley Park, "Automatic Temperature Controls," D. H. Powell, 8.15 p.m.

Tues., Oct. 9th.—BOURNEMOUTH BRANCH: Grand Hotel, Firvale Road, Bournemouth, "New Paper on Estimating," W. H. Brooks, 8 p.m.

Wed., Oct. 10th.—BIRMINGHAM BRANCH: Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, "Valves for Industry," R. G. Roach, 7.30 p.m.——HALIFAX BRANCH: Crown Hotel, Horton Street, Halifax, "Industrial Instruments," with film "Meter Manufacturing," J. Collinge, 7.30 p.m.

Thurs., Oct. 11th.—PORTSMOUTH BRANCH: Royal Beach Hotel, Southsea, "Motor Control Gear," R. F. Mathieson, 8 p.m.——S.W. LONDON BRANCH: Prince of Wales Hotel, S.W.19, "The Electrical Branch of the Royal Navy," P. A. Watson, 7.30 p.m.

Fri., Oct. 12th.—STOKE AND CREWE BRANCH: Royal Hotel, Crewe, "Space Heating by Electricity," K. G. Stephenson, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Oct. 5th.—S. MIDLANDS SECTION: North Gloucestershire Technical College, Cheltenham, "Television Lighting Effects," A. E. Robertson, 7 p.m.

Wed., Oct. 10th.—W. MIDLANDS SECTION: Technical College, Wulfruna Street, Wolverhampton, "Colour Television," 7.15 p.m.

Thurs., Oct. 11th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Digital Computer and its Applications," Dr. Barnett, 7 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Oct. 6th.—York Hall, Caxton Hall, Caxton Street, London, S.W.1, "The Study of the High Atmosphere in the International Geophysical Year," H. S. W. Massey, 6 p.m.

CHEMICAL SOCIETY

To-day, Oct. 5th.—MANCHESTER BRANCH: Chemistry Lecture Theatre, The University, Manchester, "Corrosion Fatigue," U. R. Evans, 6.30 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Oct. 9th.—Church Institute, Hull, "Epoxide Resins, their Properties and Applications," G. Swift, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Oct. 8th.—SHEFFIELD CENTRE: Medical Library, The University, Western Bank, Sheffield, 10, Chairman's Address, F. A. Benson, 6.30 p.m.

Tues., Oct. 9th.—SESSIONAL MEETING: Royal Institution, Albemarle Street, London, W.1, Presidential Address, "Lighting and Social History," W. E. Harper, 6 p.m.——LIVERPOOL CENTRE: Liverpool Engineering Society, 9, The Tempie, 24, Dale Street, Liverpool, Chairman's Address, F. J. Burns, 6 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Oct. 8th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Silicones," film and lecture, 7.30 p.m.

Tues., Oct. 9th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Industrial Drying," R. R. Clegg, 7.15 p.m.

Wed., Oct. 10th.—E. MIDLANDS BRANCH: County Hotel, Theatre Square, Nottingham, "Germany and the Fuel Problem," E. G. Phillips, 7 p.m.

Thurs., Oct. 11th.—GLASGOW BRANCH: Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, "Industrial Psychology," C. A. Oakley, 7.15 p.m.——N.E. BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "Stokers and Boilers," K. Holdsworth, 7 p.m.

Fri. to Sun., Oct. 12th to 14th.—SOUTHERN REGIONAL CONFERENCE: Grand Hotel, Bournemouth. Theme: "Future Developments in Plant Engineering."

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., Oct. 11th.—BEDS AND HERTS SECTION: W. H. Allen, Sons and Co., Ltd., Bedford, Presidential Address, A. F. Hammond, followed by films, 7.30 p.m.

Fri., Oct. 12th.—TEES-SIDE BRANCH: Teesdale Hall, Head, Wrightson and Co., Ltd., Thornaby-on-Tees, "Foremanship," F. Shepherd, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., Oct. 9th.—85, Minories, London, E.C.3, Presidential Address, "Marine Engineering as a part of the Shipping Industry," Sir Donald F. Anderson, 5.30 p.m.

Wed., Oct. 10th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "General Observations on Marine Machinery," N. J. H. D'Arcy, 7.30 p.m.——MERSEYSIDE AND N.W. SECTION: Central Public Libraries, William Brown Street, Liverpool, "Fire in Cargo Ships," A. M. Bennett, 6.30 p.m.

Thurs., Oct. 11th.—KINGSTON UPON HULL AND E. MIDLANDS SECTION: Royal Station Hotel, Kingston upon Hull, "Some Experiences Gained Whilst Burning Oil Under Marine Boilers," R. B. Cooper, 7.30 p.m.——N.E. COAST SECTION: Stephenson Buildings, King's College, Claremont Road, Newcastle upon Tyne, "Some Cases of Marine Insurance and Salvage," Gavin Black, 6.15 p.m.——W. MIDLANDS SECTION: Exchange and Engineering Centre, Stephenson Place, Birmingham, "Oil Firing for Boilers," L. Baker, 7 p.m.

INSTITUTE OF METALS

Mon., Oct. 8th.—SCOTTISH LOCAL SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Metallurgical Problems in the Heavy Organic Chemical Industry," W. L. Wood, 6.30 p.m.

Tues., Oct. 9th.—S. WALES LOCAL SECTION: Department of Metallurgy, University College, Singleton Park, Swansea, Chairman's Address, "The Inventions of Bessemer in Relation to Non-Ferrous Metals," H. O'Neill, 6.45 p.m.

INSTITUTE OF NAVIGATION

Tues., Oct. 16th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, Annual General Meeting, Presidential Address, "The Place of Navigation in Modern Air Transport," A. M. A. Majendie, 3 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Oct. 8th.—E. REGIONAL CENTRE: Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, "Two-Way Radio as an Aid to the Control of Goods and Passenger Vehicles," E. N. Farrar, 7.30 p.m.

Tues., Oct. 9th.—MIDLANDS CENTRE: Exchange and Engineering Centre, Stephenson Place, Birmingham, "Current Trends in Fuel Injection Equipment for Road Transport," J. Skinner, 7.30 p.m.——WESTERN CENTRE: Royal Hotel, Bristol, "The Design and Construction of a Modern Goods-Carrying Vehicle," A. S. C. Marks, 7.30 p.m.

Thurs., Oct. 11th.—W. REGIONAL CENTRE: Adelphi Hotel, Lime Street, Liverpool, "The Use of Glass Fibres with Polyenether Resin in Vehicle Bodies," A. R. Henning, 7.30 p.m.

Mon., Oct. 15th.—SCOTTISH CENTRE: North British Hotel, Edinburgh, "Wear and Tear," J. Johnson, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Oct. 16th.—Geological Society, Burlington House, London, W.1, "Liquid-Liquid Extraction," R. Gayler and H. R. C. Pratt, 5.30 p.m.——N.W. BRANCH: Reynolds Hall, College of Technology, Manchester, "A Method of Design of Continuous Through-Circulated Dryers," H. C. Glover and A. A. H. Moss, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Oct. 9th.—MARITIME AND WATERWAYS MEETING: Great George Street, Westminster, London, S.W.1, "Factors Influencing the Choice of the Light Dredger," J. A. Ringers, 5.30 p.m.

Tues., Oct. 16th.—RAILWAY MEETING: Great George Street, Westminster, London, S.W.1, "Some Methods of Extending the Life of Bridges by Repair or Strengthening," J. D. West, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Tues., Oct. 9th.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, Chairman's Address, "The Measurement of Radioactivity," Denis Taylor, 5.30 p.m.

Wed., Oct. 10th.—N. SCOTLAND SUB-CENTRE: Caledonian Hotel, Aberdeen, Chairman's Address, F. M. Bruce, 7.30 p.m.

Thurs., Oct. 11th.—N. SCOTLAND SUB-CENTRE: Electrical Engineering Department, Queen's College, Dundee, Chairman's Address, F. M. Bruce, 7 p.m.——UTILIZATION SECTION: Savoy Place, London, W.C.2, Chairman's Address, "Balanced Development and Diversity of Applications," H. J. Gibson, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Oct. 8th.—N.E. BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Oil Seals and Packings from the Designers' Point of View," E. T. Jagger, 7.15 p.m.

Thurs., Oct. 11th.—39, Portland Place, London, W.1, "Design in Reinforced Plastics," S. F. Page, 6.45 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Tues., Oct. 9th.—BIRMINGHAM AND DISTRICT BRANCH: Exchange and Engineering Centre, Stephenson Place, Birmingham, "Dust Control in Foundries," W. D. Bamford, 6.30 p.m.——S.W. BRANCH: R.W.A. School of Architecture Library, Bristol, "Some Aspects of Intermittent Heating," E. Harrison, 6.30 p.m.

Wed., Oct. 10th.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Mechanical Services for Large Office Buildings," L. C. A. Walford, 6 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Oct. 5th.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "Highway Engineering from a County Angle," I. A. Cram, 5.30 p.m.——N.E. BRANCH: The University, Palace Green, Durham City, "Heavy Haulage by Road Transport," E. G. Milne, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Oct. 5th.—SCOTTISH BRANCH: North British Station Hotel, Edinburgh, "A Criticism of the Technical Education of Recently Qualified Engineers," P. P. Love, 6.30 p.m.

Tues., Oct. 9th.—AUTOMOBILE DIVISION, GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, Address by the Chairman, 6 p.m.

Wed., Oct. 10th.—YORKSHIRE GRADUATES' SECTION: Visit to A. Cooke, Ltd., Leeds, 2.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Oct. 11th.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, "Scale Effect Experiments on Victory Ships and Models," Part II, "Analysis of Wake Measurements on a Model Family and the Model Boat, D. C. Endert, Jr.," J. D. van Manen, 4.45 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Mon., Oct. 8th.—JUBILEE MEETING: Institution of Electrical Engineers, Savoy Place, London, W.C.2, President's Address, "Fifty Years of Telecommunications," 5 p.m.

IRON AND STEEL INSTITUTE

To-day, Oct. 5th.—IRON AND STEEL ENGINEERS' GROUP: Grand Pavilion, Porthcawl, "The Planned Change-over of a High-Lift Slabbing to a Universal Mill," C. E. H. Morris and R. N. Dale, 9.30 a.m. to 12.15 p.m.; Esplanade Hotel, Porthcawl, Luncheon, 12.30 p.m. to 1.30 p.m.; Visits to Margam and Abbey Works of the Steel Company of Wales, Ltd., 1.45 p.m. to 4.45 p.m.

Fri., Oct. 12th.—CORROSION MEETING: 4, Grosvenor Gardens, London, S.W.1. 10 to 11 a.m., "The Corrosion Resistance of Low-Alloy Steels," J. C. Hudson and J. F. Stanners; 11 a.m. to 12 noon, "The Corrosion Resistance of Wrought Iron," J. P. Chilton and U. R. Evans; 12 noon to 12.15 p.m., interval; 12.15 to 1.15 p.m., "Corrosion Resistance of Some Austenitic Cr-Ni Steels of 18/8/Ti Composition: The Effect of Variation in Chemical Composition and Thermal Treatments," E. J. Heeley and A. T. Little; 1.15 to 2.30 p.m., Buffet Lunch; 2.30 to 3.30 p.m., "Effects of Sulphate-Chloride Mixtures in Fuel Ash Corrosion of Steels and High-Nickel Alloys," H. T. Shirley; 3.30 to 4.45 p.m., "The Stress-Corrosion Cracking of Austenitic Stainless Steels," Part, I, "Mechanism of the Process in Hot Magnesium-Chloride Solutions," T. P. Hoar and J. G. Hines; Part II, "Fully Softened, Strain-Hardened, and Refrigerated Material," J. G. Hines and T. P. Hoar.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Oct. 5th.—FILM EVENING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Plastic Pipelines," and "The Papermakers," 7 p.m.

Mon., Oct. 8th.—SHEFFIELD AND DISTRICT SECTION: Livesey Clegg House, 44, Union Street, Sheffield, 1, Chairman's Address and Annual General Meeting; "A Development of the Motor Industry," H. C. Bentley, 7.30 p.m.——N.W. SECTION: Engineers' Club, Albert Square, Manchester, Annual General Meeting; Presidential Address, T. S. Dickinson, 7.30 p.m.

Fri., Oct. 12th.—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Problem of O and M Study," W. J. Kease, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Mon., Oct. 8th.—Engineers' Club, Albert Square, Manchester, Inaugural Address by the President, G. R. Adamson, 6.45 p.m.

Wed., Oct. 10th.—Visit to British Oxygen Gases, Ltd., Worsley, 2.30 p.m.

Fri., Oct. 12th.—Visit to Joseph Adamson and Co., Ltd., Hyde, 2.30 p.m.——STUDENTS' SECTION: Engineers' Club, Albert Square, Manchester, "The History and Future Development of Education for Engineering," H. Wright Baker, 7.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Oct. 12th.—GENERAL MEETING: Mining Institute, Newcastle upon Tyne, Presidential Address, R. C. Thompson, 6.15 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Oct. 11th.—The Temple, Dale Street, Liverpool, Presidential Address, W. Rose, 7 p.m.

LONDON ASSOCIATION OF ENGINEERS

Sat., Oct. 6th.—Fullers' Restaurant, 206, Regent Street, London, W.1, "Atomic Energy and the Engineer," W. R. Wootton. Film of the New Atomic Power Station at Calder Hall, 6 p.m.

NEWCOMEN SOCIETY

Wed., Oct. 10th.—Science Museum, Exhibition Road, South Kensington, London, S.W.7, "The Origin of the Differential Gear and its Connection with Equation Clocks," H. von Bertele, 5.45 p.m.

OLD CENTRALIANS

Mon., Oct. 15th.—The Mapleton Restaurant, Coventry Street, London, W.1, "Population," C. M. R. Balbi, 12.45 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Oct. 9th.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "The Pressure Jet Helicopter," A. Stepan, 7 p.m.

Wed., Oct. 10th.—GRADUATES' AND STUDENTS' SECTION: 4, Hamilton Place, London, W.1, "Service Flight Testing of High-Speed Aircraft," P. D. Thorne, 7.30 p.m.

Thurs., Oct. 11th.—HENLOW BRANCH: Building 62, R.A.F., Technical College, Henlow, "Rocket Motors," S. Allen, 8 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

To-day, Oct. 5th.—MINING SURVEYORS GENERAL MEETING: 12, Great George Street, Westminster, London, S.W.1, "Sand and Gravel," H. K. Watson; "Ironstone Mining," R. R. Beilby; "Ball Clay Production," C. P. Bates, 5.45 p.m.

Mon., Oct. 8th.—VALUATION AND GENERAL RATING MEETING: 12, Great George Street, Westminster, London, S.W.1, "Some Aspects of the Valuation of Licensed Property," M. F. G. Gibbs, 5.45 p.m.

SOCIETE DES INGENIEURS CIVILS DE FRANCE

Thurs., Oct. 11th.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "The Reconstruction of Bridges in France During and After the 1939–45 War with Particular Reference to Site Organisation and Conditions," Rene Breffeil, 6 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

To-day, Oct. 5th.—FAWLEY SECTION: Copthorne House, Fawley, Hants, "Electrically Operated Process Control Equipment," R. J. Redding, 7 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Oct. 19th.—39, Elmbank Crescent, Glasgow, Symposium on the Application of Low-Alloy Steels for Welded Pressure Vessels, 10 a.m.